THE

ORGANIZATION AND VALUATION

OF

FORESTS,

ON THE CONTINENTAL SYSTEM,

IN THEORY AND PRACTICE.

BY

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PREFACE.

THE systematic management of forests has long attracted so much attention in England and her dependencies that a short account of the methods of organization practised on the Continent of Europe may perhaps be interesting to many English-speaking foresters both at home and abroad.

A knowledge of Sylviculture is presupposed; * but, as an English forest terminology has not yet been fully established, and many terms have only recently been introduced, the meanings to be given to nearly all technical sylvicultural expressions used in this book have been explained.

In Part I. the methods employed in valuing forests, and the general principles on which their organization depends, are explained.

* The only book I know on this subject in English is Bagneris' "Sylviculture," translated from the French by Messrs. Fernandez and Smythies.

In the Second Part I have attempted, while avoiding unnecessary detail, to describe the principal practical methods and all essential operations of organization, excepting those of surveying. The methods which may be followed in surveying forest-areas are in nowise different from those employed in land-surveying generally; and as treatises on the subject, by writers much more competent than I am to deal with it, already exist, I have not thought it necessary to enter into particulars regarding this important branch of organization.

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DEFINITION.

THE object of organisation is to enable the proprietors of forest estates to utilize their lands to the greatest advantage.

The subject is divisible into two parts, the one treating of General Principles, the other of the Survey and Examination of Forests, together with the application of general rules in their management.

PART I.—GENERAL PRINCIPLES.

CHAPTER I.

THE MODEL FOREST.

IMAGINE a uniformly productive tract, divided into any number (n) of divisions, or compartments, of equal area; the first stocked with trees one year old, the second with trees two years old, and so on in an ascending series up to the nth compartment stocked with trees n years old. And let the revolution, or age at which the trees of any compartment are to be cut, be n years. The land will then be parcelled out into a number of compartments equal to the number of years in the revolution, and each one will be stocked

with trees one year older than those of a compartment immediately preceding it in age, so that there will be a complete series of groups of all ages from 1 to n years old. If, now, all trees n years old, that is those in the nth compartment, be cut, and the land immediately re-stocked with young growth, it is evident that, at the end of twelve months, the group of trees next in order of age, or $n - 1$ years at the time of the first cutting, will have advanced to maturity, while the plants on the first coupe will have taken the place of the youngest group in the series, and the plants of all intermediate compartments have advanced one year in age. At the expiration of twelve months from the time of the first cutting, we may, therefore, again cut a group n years old, and so on for ever, cutting a group n years old once a year without diminishing the standing stock. The yearly produce thus obtained is, in fact, the annual growth, or interest, of the material standing on n compartments, and is called the sustained yield, and a forest so organized is called a *model*, or *ideal* forest, because it represents a state of things which is theoretically perfect, if never quite attainable in practice.

If, in the case just considered, we were to cut more than the sustained yield in any year, we would be trenching on the capital stock and unable to maintain an unvarying yield. If, on the other hand, we were to cut less, we would not be working up to the full capability of the forest and have a certain amount of capital, in the form of trees, lying idle, and, for the time being, unremunerative.

CHAPTER II.

INCREMENT.

A FOREST may, therefore, be regarded in the light of a capital producing by its yearly growth a certain interest in wood, just as a sum of money which is lent out produces interest; and, in estimating the growth of a forest viewed as a productive money-capital, the rate is calculated in precisely the same way as in ordinary money transactions. If, for instance, a quantity, m, grows in n years to a quantity M, at a certain rate per cent. per annum, p, we shall have, according to the rules of compound interest,

$$M = m \times 1{\cdot}0p^n.$$

For an investment of 100 units becomes at the end of the first year, $100 + p$, and therefore m units become $m\left(\frac{100+p}{100}\right)$, because $100 : 100 + p :: m : x$. By the end of the second year $m\left(\frac{100+p}{100}\right)$ will have become $m\left(\frac{100+p}{100}\right)^2$, according to the proportion $100 : 100 + p :: m\frac{(100+p)}{100} : x$. In the same way, at the end of the third year the value of m is found to be $m\left(\frac{100+p}{100}\right)^3$, and, generally, at the end of any year, n, the capital, m, will have grown to $m\left(\frac{100+p}{100}\right)^n$, that is to say, to $m \times 1{\cdot}0p^n$; and any three of the four magnitudes being known we can find the fourth.

Thus: $$p = 100\left(\sqrt[n]{\frac{M}{m}} - 1\right).$$

And, $$n = \frac{\log M - \log m}{\log 1{\cdot}0p}.\text{*}$$

* Some writers estimate the percentage of the woody growth of forests by means of this formula. This is evidently wrong. The

To save time and trouble, Pressler recommends the use of the formula $p = \frac{M-m}{M+m} \times \frac{200}{n}$. This he finds by assuming that the mean mass $(\frac{M+m}{2})$ is to the mean increment $(\frac{M-m}{n})$ as 100 is to p. The formula does not give very accurate results; but is sufficiently reliable for all practical purposes.*

percentage of woody growth and that on investments are two very different things. The proper way of estimating the former for any period is by the proportion $M : M - m :: 100 : p$.

* Pressler distinguishes three kinds of increment in value: the first due to an increase of the quantity of wood; the second, to its superior quality when older, and the third, to a rise in the money-value of wood.

Example.—A group would yield, if cut now, 100 cubic feet; if cut ten years hence, 150 cubic feet of wood. The present average nett value of a cubic foot is 2*s.* Ten years hence, it is estimated to be 3*s.*, in addition to a rise of 10 per cent. in the price of all descriptions of wood.

At the end of the ten years, the increment of the group will be:

				s.
Increment due to	quantity	....	$(150 - 100)\ 2 =$	100
Ditto do.	quality	....	$150 \times 1 =$	150
Ditto do.	rise of prices	...	$150 \times \frac{3 \times 10}{100} =$	45
Total increment		....		295

The increase in quantity is, of course, due to the growth of the tree or group. That due to quality is mainly dependent on the higher prices which are generally commanded by large trees compared with smaller ones; as, for instance, when trees, previously large enough only for firewood, having grown into poles suitable for roofing, or when poles having grown into timber suitable for larger structures, command ever-increasing prices. Again, the introduction or revival of an industry, in or near a forest,—as, for example, gold-mining or iron-smelting,—might cause a great rise in the value of certain descriptions of wood used in its development. In timber forests, the percentage of superior descriptions generally increases very considerably with the age of the trees, and, other things being equal, causes a rise in quality.

Example.—In the Table on page 6, the yield, exclusive of thinnings, of a group forty years old, is shown as 458 cubic feet, valued at 352·9*s.*; that of a group fifty years old, as 641 cubic feet of wood, of the value of 582·4*s.*; what is the rate of growth per cent. per annum?*

By formula 1,

$$p = 100 \quad \left(\sqrt[10]{\frac{582 \cdot 4}{352 \cdot 9}} - 1 \right)$$
$$= 5 \cdot 1$$

By formula 2,

$$p = \frac{582 \cdot 4 - 352 \cdot 9}{582 \cdot 4 + 352 \cdot 9} \times \frac{200}{10} = 4 \cdot 9$$

The increment due to a general rise in the price of all descriptions of wood may be owing, amongst other causes, to improved methods of exportation, or to improved communications; as, for instance, when a road or railway, on being started in or near a forest, enhances the value of all kinds of produce.

* Trees of about the same age and height, growing together in a mass, or trees growing in a sub-compartment, are called a *group*. A compartment may contain one or more groups; if more than one, the area occupied by each group is called a sub-compartment. The group is the smallest unit of mass, and the sub-compartment the smallest of area, in regular forests.

TABLE ILLUSTRATING THE RECEIPTS FROM, AND EXPENDITURE ON, A GROUP.

Age of Group.	Yield of material, cubic feet. Principal cuttings.	Thinnings.	Total yield.	Value, after deducting cutting expenses of One cubic foot of Principal cutting	Minor cutting	Total cubic contents of Principal cutting	Minor cutting	Sum of values of thinnings at 3% compound interest in the n-th year.	Value of principal cuttings and thinnings together in the n-th year, with interest.	Cost of cultivation at compound interest in the n-th year. $10\times1{\cdot}03^n$	Total receipts, after deducting cost of cultivation, in the n-th year.	$\frac{1{\cdot}03^n-1}{0{\cdot}03}$	Annual return equivalent to k. $\frac{k}{l}$	Average yield per annum. $\frac{a+\Sigma(b)}{n}$ Cubic feet.	$\frac{f+\Sigma(g)-x-nw}{n}$ Shillings.	Prospective land value. $\frac{m-v}{0{\cdot}03}$ Shillings.	Index for periods of ten years and B = 166·67	Average yearly return per cent. on capital-outlay.
								Shillings.										
n.	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	o.	p.	q.	r.	s.
10	40	...	40	...	...	...	...	...	...	...	...	...	...	...	...			
20	87	...	87	0·51	...	41·1	...	...	44·4	18·1	26·3	26·87	...	...	...			
30	232	25	257	0·54	0·54	125·3	13·5	13·5	138·8	24·3	114·5	47·58	2·4	8·6	2·3	13·3		1·17
40	406	52	458	0·8	0·54	324·8	28·1	46·2	371·0	32·6	338·4	75·40	4·5	12·1	6·9	83·3	4·97	1·98
50	580	61	641	0·92	0·8	533·6	48·8	110·9	644·5	43·8	600·7	112·80	5·33	14·1	10·3	111·0	3·83	2·32
60	783	58	841	1·04	0·92	814·3	53·4	202·4	1016·7	58·9	957·8	163·05	5·8	16·3	13·8	126·6	3·64	2·54
70	957	52	1009	1·29	1·12	1231·5	58·2	330·2	1564·7	79·2	1485·5	230·59	6·5	17·2	18·4	150·0	3·79	2·77
80	1102	49	1151	1·64	1·23	1807·3	60·3	504·1	2311·4	106·4	2205·0	321·36	6·9	17·5	23·8	163·3	3·63	2·94
90	1247	46	1293	2·0	1·6	2491·0	73·6	751·1	3245·1	113·0	3102·1	443·35	7·0	17·7	29·3	166·6	3·21	3·00
100	1363	46	1409	[illegible]	2·0	3271·2	92·0	1101·5	4372·7	192·2	4180·5	607·29	6·9	17·5	31·9	163·3	2·81	2·95
110	1479	46	1525	2·8	2·4	4141·2	110·4	1590·8	5732·0	258·3	5473·7	827·61	6·6	17·4	40·5	153·3	2·51	2·84
120	1566	...	1566	3·2	...	5011·2	...	2138·0	7149·2	347·1	6802·1	1125·70	6·0	16·7	41·2	133·3	1·86	2·61

CHAPTER III.

THE REVOLUTION.

THE term *revolution* is used to denote the period of years which has been *fixed* to elapse from the time of the production of a tree, or group, to the time of its being cut down. It does not necessarily correspond to the age at which a tree is harvested, because trees sometimes have to be cut, or fall from natural causes, before the revolution fixed upon is completed.

The length of the revolution may depend on many things; such as the kind of tree, and the method of regeneration to be followed—subjects which are fully examined in books on sylviculture—and the special objects of the proprietor.

The principal objects of the latter may be classed as follows:—

To obtain from the land the largest possible average annual return, (1) of material, (2) of money, (3) of interest on his capital invested; or, to adopt the revolution best suited to (4) natural regeneration, or some (5) special technical purpose. Revolutions fixed with a view to meet such special requirements are called, respectively: the revolution of the largest mean yearly yield, (1) in wood and (2) money; (3) the financial revolution, (4) the physical, and (5) the technical.

THE REVOLUTION OF THE LARGEST RETURN IN WOOD.

By dividing the cubic contents of a tree, or forest, by its age, we get what is called its average annual

This formula is deducible from the preceding one.

Example.—A plantation now three years old has no immediate value in the market, but if cut and sold ten years hence will, it is estimated, be worth 50 shillings nett. What is its present value at 3 per cent. discount?

Here $M = 50, n = 10, p = 3$

$$m = \frac{50}{1{\cdot}03^{10}}$$
$$= 37{\cdot}2s.$$

If a given rent, R, falls due every year for n years, the sum, S, of all these yearly rents will amount in the nth *year at compound interest to*

$$\frac{R\,(1{\cdot}0\,p^n - 1)}{0{\cdot}0\,p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For $S = R + R\,1{\cdot}0\,p + R\,1{\cdot}0\,p^2 + \ldots\ldots + R\,1{\cdot}0\,p^{n-1}$

which is an ascending geometrical series, and may be summed by formula A, or

$$S = a\,\frac{r^n - 1}{r - 1}$$

Here $a = R, r = 1{\cdot}0\,p$, and $n = n$

$$S = R\,\frac{1{\cdot}0p^n - 1}{1{\cdot}0p - 1}$$
$$= R\,\frac{(1{\cdot}0\,p^n - 1)}{0{\cdot}0p}.$$

Example.—The yearly receipts on account of the sale of grass in a forest amount to 2*s.* What sum do these rents amount to at the end of fifty years, interest being calculated at 3 per cent.?

Here $R = 2, p = 3$, and $n = 50$

$$S = \frac{2\,(1{\cdot}03^{50} - 1)}{0{\cdot}03}$$
$$= 225{\cdot}6s.$$

II. Perpetual Rents.

The present value, **V**, *of a rent,* **R**, *due in twelve months, and after that every year is*

$$\frac{R}{0{\cdot}0p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

For $$V = \frac{R}{1{\cdot}0p} + \frac{R}{1{\cdot}0p^2} + \&c.$$

which is a descending geometrical series, whose sum will be found by the formula (C) for finding the sum of an infinite progression, $S = \frac{a}{1-r}$.

Here $$a = \frac{R}{1{\cdot}0p}, \; r = \frac{1}{1{\cdot}0p}$$

$$V = \frac{\frac{R}{1{\cdot}0p}}{1 - \frac{1}{1{\cdot}0p}} = \frac{R}{0{\cdot}0p}$$

Example.—A forest yields a nett yearly income of 500 shillings. What capital does this income represent at 3 per cent. interest?

Here $$R = 500, \; p = 3.$$

$$V = \frac{500}{0{\cdot}03} = 16666{\cdot}7s.$$

The present value, V, *of a rent,* R, *which falls due every* n *years from the present time is*

$$\frac{R}{1{\cdot}0p^n - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Here $$V = \frac{R}{1{\cdot}0p^n} + \frac{R}{1{\cdot}0p^{2n}} + \&c.$$

and is discounted in the same way as that employed in the preceding case by the formula

$$S = \frac{a}{1 - r}$$

Here $$r = \frac{1}{1{\cdot}0p^n}$$

And $$V = \frac{\frac{R}{0p^n}}{1 - \frac{1}{1{\cdot}0p^n}} = \frac{R}{{\cdot}0p^n - 1}$$

Example.—A compartment yields every fifty years 580 cubic feet of wood, worth 325 shillings nett. What is the value at the beginning of the revolution of this periodical income at 3 per cent. discount ?

Here $$R = 325, p = 3, n = 50.$$

$$V = \frac{325}{1{\cdot}03^{50} - 1} = 96.$$

The present value, V, *of a rent,* R, *which falls due for the first time* m *years hence, but after that every* n *years is*

$$\frac{R\,1{\cdot}0p^{n-m}}{1{\cdot}0p^{n} - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Here $$V = \frac{R}{1{\cdot}0p^{m}} + \frac{R}{1{\cdot}0p^{m+n}} + \frac{R}{1{\cdot}0p^{m+2n}} + \&c.$$

which may be summed by the formula $\frac{a}{1-r}$

$$\therefore \qquad V = \frac{\frac{R}{1{\cdot}0p^{m}}}{1 - \frac{1}{1{\cdot}0p^{n}}} = \frac{R\,1{\cdot}0p^{n-m}}{1{\cdot}0p^{n} - 1}.$$

Example.—What is the present value of a thinning worth 10 pounds nett, which first falls due 10 years hence, but after that every fifty years ? Interest and discount 3 per cent.

Here $$R = 10, n = 50, m = 10$$

$$V = \frac{10 \times 1{\cdot}03^{50-10}}{1{\cdot}03^{50} - 1}$$

$$= 9{\cdot}6.$$

The present value, V, *of a sum,* R, *which first falls due now, and afterwards every* n *years, is*

$$\frac{R\,1{\cdot}0p^{n}}{1{\cdot}0p^{n} - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

For $$V = R + \frac{R}{1{\cdot}0p^{n}} + \frac{R}{1{\cdot}0p^{2n}} + \quad . \quad . \quad . \quad .$$

which may be summed by the formula $\frac{a}{1-r}$

Therefore
$$V = \frac{R}{1 - \frac{1}{1{\cdot}0p^n}} = \frac{R\,1{\cdot}0p^n}{1{\cdot}0p^n - 1}$$

Example.—The cost of cultivating an acre of land with trees subject to a revolution of 50 years is 20 shillings. What is the capital necessary to cover this charge permanently? Interest 3 per cent.

Here $R = 20, n = 50, p = 3.$
$$V = \frac{20 \times 1{\cdot}03^{50}}{1{\cdot}03^{50} - 1}$$
$$= 26.$$

III. Conversion of Periodical Rents into Yearly Rents.

The yearly rent, r, *corresponding to a periodical rent,* R, *which falls due every* n *years, is found by the formula*

$$r = \frac{R}{1{\cdot}0p^n - 1}\,0{\cdot}0p \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Find, by formula (5), the present value of all the rents, and then convert the amount so found into a yearly rent by formula (4), thus :—

Present value, $= \frac{R}{1{\cdot}0p^n - 1}$

Present value converted into a perpetual rent
$$= \frac{R}{1{\cdot}0p^n - 1} \times 0{\cdot}0\,p.$$

Example.—A forest will yield 50 years hence, and after that every 50 years, a nett income of 350*s*. What yearly income does this periodical rent represent? Interest 3 per cent.

Here $R = 350, n = 50, p = 3$
$$r = \frac{350}{1{\cdot}03^{50} - 1} \times 0{\cdot}03$$
$$= 3{\cdot}1$$

If, in the above case, the rent, R, *were to fall due for*

the first time in m *years, but after that every* n *years, then,*

$$r = \frac{R\ 1{\cdot}0p^{n-m}}{1{\cdot}0p^{n} - 1}\ 0{\cdot}0\,p \quad . \quad . \quad . \quad . \quad (9)$$

Here we find the present value of R by means of formula (6), and convert the sum so found into a yearly rent by formula (4).

Example.—Find the yearly income derivable from a thinning worth 100*s.* nett, which falls due 10 years hence, but after that every 50 years. Interest 3 per cent.

Here $R = 50,\ n = 50,\ m = 10$

$$r = \frac{100 \times 1{\cdot}03^{50-10}}{1{\cdot}03^{50} - 1} \times 0{\cdot}03$$
$$= 2{\cdot}9$$

If in case (7) *the rent,* R, *were first to fall due now, but after that every* n *years, we should have*

$$r = \frac{R\ 1{\cdot}0p^{n}}{1{\cdot}0p^{n} - 1}\ 0{\cdot}0p \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Here we first find the present value of R by formula (7), and convert the result into a yearly rent by formula (4).

Example.—The cost of planting an acre of land with trees subject to a revolution of 50 years is 20*s.* What yearly payment at 3 per cent. interest does this periodical charge represent?

Here, $R = 20,\ n = 50,\ p = 3$

$$r = \frac{20 \times 1{\cdot}03^{50}}{1{\cdot}03^{50} - 1} \times 0{\cdot}03$$
$$= {\cdot}6.$$

The above ten formulæ will be found sufficient to solve all important problems of organisation, and we may now continue our examination of the revolution.

The Financial Revolution.

In this case we have to find the revolution affording the highest return on the capital-outlay.

The most favourable revolution from a mercantile point of view will be that which affords the largest return after deducting from the present value of the receipts the present value of all expenditure.

A.—The Outlay.

The outlay on a group from the time of its foundation to the time of its being cut, consists in :—

(1). A sum of money (B) representing the value of the land.

(2). A sum of money (c) spent in cultivating the land.

(3). A sum of money (V) necessary to defray annually-recurring charges (such as those of taxes and supervision) during the revolution.

(1). *The Value of the Land.*

To determine this, we may take its

(*a*). Market-value.
(*b*). Cost-value (cost-price).
(*c*). Prospective-value.

(*a*). *The market-value* may be ascertained from records of recent auction-sales of land, similar as regards situation and quality.

(*b*). *The cost-value* is the amount actually paid for the bare land.

(*c*). *The prospective-value* is equal to the present value of all sums receivable during the revolution,

minus the value at the same time of all sums expended during the revolution.

The receipts and expenditure do not all fall due at one and the same time: to balance the accounts, therefore, it is necessary to reduce all values to one date. This may be done as follows :—

Let H_r represent the nett value* of the main-cutting of a compartment: r the revolution : $D_a, D_b, \ldots D_n$, the nett values of all minor receipts in the years a, b, ... n. At the end of the revolution, that is, in the year r, the receipts will amount to

$$H_r + D_a 1{\cdot}0\,p^{r-a} + D_b 1{\cdot}0\,p^{r-b} + \ldots + D_n 1{\cdot}0\,p^{r-n}$$

The cost of cultivation (c) will have mounted up to $c\ 1{\cdot}0\,p^r$ in the r-*th* year, and must be deducted from the above expression. We shall then have the value of the receipts in the year r reduced to

$$H_r + D_a 1{\cdot}0\,p^{r-a} + D_b 1{\cdot}0\,p^{r-b} + \ldots + D_n 1{\cdot}0\,p^{r-n} - c\ 1{\cdot}0\,p^r$$

By dividing this expression by $1{\cdot}0\,p^r - 1$ (see formula 5) we get its value at the beginning of the revolution, namely,

$$\frac{H_r + D_a 1{\cdot}0\,p^{r-a} + D_b 1{\cdot}0\,p^{r-b} + \ldots + D_n 1{\cdot}0\,p^{r-n} - c\ 1{\cdot}0\,p^r}{1{\cdot}0\,p^r - 1}$$

There remains to be deducted the yearly-recurring expenditure, v, on account of supervision, taxes, &c., which is represented at the beginning of the revolution by a capital equal to $v \times 0{\cdot}0\,p$ (see formula 4).

The nett prospective-value of the land, B_p, is, therefore,

* Nett value here means after deducting cost of harvesting.

$$B_p = \frac{H_r + D_a 1{\cdot}0p^{r-a} + D_b 1{\cdot}0p^{r-b} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - \frac{v}{0{\cdot}0p}$$

Or if $\frac{v}{0{\cdot}0p} = V.$

$$B_p = \frac{H_r + D_a 1{\cdot}0p^{r-a} + D_b 1{\cdot}0p^{r-b} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V$$

(2). *The Cost of Cultivation.*

This is found in the same way as that employed in the last paragraph. It is represented by a capital equal to

$$\frac{c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1}$$

when c is the charge at the beginning of each revolution.

(3). *Yearly Expenditure.*

As shown above, this is represented by a capital, V, which is the capitalized value of the yearly expenditure, or $\frac{v}{0{\cdot}0p}$.

B.—The Receipts.

These consist in the main-cutting, H_r, at the end of the revolution, r, and all intermediate cuttings, D_a, D_b, &c., in the years a, b, &c., they are calculated in the same way as that which was employed in finding the prospective land-value.

The financial revolution will, therefore, be that which gives to the formula

$$\frac{H_r + D_a 1{\cdot}0p^{r-a} + D_b 1{\cdot}0p^{r-b} + \ldots + D_n 1{\cdot}0p^{r-n}}{1{\cdot}0p^r - 1} - \left(B + V + \frac{c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1}\right)$$

the highest value.

(2). Natural Regeneration Coupes.

Here old and young growth are mixed up on the coupes, and it is necessary to separate the portion in process of regeneration from the other classes. Let c represent the portion undergoing reproduction, and m the period required for its completion. The ordinary classes, c, c, will be each $n\frac{A}{r}$ acres, as before; c' will have an area $\frac{A \times m}{r}$, and in reality belong partly to the youngest and partly to the oldest ordinary classes.

If m is less than n, the area occupied by Class I. will be $\frac{A(n-m)}{r}$.

If m is equal to, or greater than, n, there will be no first class, and at the end of the term required for regeneration c' will jump at once into a higher class.

Example.—A forest, subject to natural regeneration, has an area of 800 acres and a revolution of eighty years. What is the size of its age-classes when $n = 20$, and groups take (1) eight, (2) twenty, or (3) twenty-five years to regenerate?

(1)

$$\begin{aligned} \text{I} &= \frac{800}{80}(20-8) &&= 120 \\ \text{II} &= 10 \times 20 &&= 200 \\ \text{III} &= 10 \times 20 &&= 200 \\ \text{IV} &= 10 \times 20 &&= 200 \\ c' &= 10 \times 8 &&= 80 \\ & \text{Total} && 800 \text{ acres.} \end{aligned}$$

(2)

$$\begin{aligned} \text{I} &= \frac{800}{80}(20-20) &&= 0 \\ \text{II} &= 10 \times 20 &&= 200 \\ \text{III and IV} &, 200 \text{ each} &&= 400 \\ c' &= 10 \times 20 &&= 200 \\ & \text{Total} && 800 \end{aligned}$$

(3)	I =	= 0
	II = 10 × (2 × 20 − 25)	= 150
	III and IV each 200	= 400
	c' = 10 × 25	= 250
	Total	800

(3). Coppice.

For coppice, the range of age in a class is generally much smaller than for seedling-forest, the revolution seldom exceeding thirty years. The gradations may therefore be taken for periods of five or ten years. The size of the age-class is found in the same manner as for seedling-forest with clean cuttings and immediate regeneration, namely, by the formula $n\frac{A}{r}$.

(4). Underwood with Overwood.

For coppice with standards, it is usual to choose the revolution of the overwood so that it shall be a multiple of that of the underwood. For the underwood, the area of an age-class is, $n\frac{A}{r}$, the same as for coppice pure and simple; but the area occupied by classes of overwood cannot be determined in a practical way, because the classes are mixed up—a confused mass of trees of all ages occurring on the same coupe.

The area which should be occupied by each age-class in the model-forest may, however, be shown in the following manner.

The oldest coupe of the underwood of a model-forest, will contain standards of the following ages :—

	r,	$2r$,	$3r$, ...	mr
The next in age of	$r-1$,	$2r-1$,	$3r-1$, ...	$mr-1$
The third oldest of	$r-2$,	$2r-2$,	$3r-2$, ...	$mr-2$

And so on, down to the last coupe of the underwood, with group $r - r = 0$ years old, which will contain standards—

$$r - r,\ 2r - r,\ 3r - r, \ldots \ldots, mr - r, \text{ years old.}$$

that is to say,

$$0,\ r,\ 2\,r,\ \ldots \ldots,\ (m - 1)\,r, \text{ years old.}$$

when $r =$ revolution of the underwood, mr that of the overwood.

There will, therefore, be a complete series of standards of all ages from 1 to mr years old. If, now, we assume that each class occupies an equal area, as in the model-forest it would do, and if the standards are regarded in the light of open forest occupying the whole of the area, one year's coupe will be $\frac{A}{mr}$ in size, and the area occupied by each age-class will be $n\frac{A}{mr}$.

For a forest 100 acres in extent, with a revolution for its coppice of ten years, and one of forty for its standards, the yearly underwood coupe will be $\frac{100}{10} = 10$ acres.

The overwood-coupe would be $\frac{100}{40} = 2\frac{1}{2}$ acres.

If the age-classes are taken for periods of five years each, there would be—

Class I. Underwood (trees 1 to 5 years old) $\frac{5 \times 100}{10} = 50$ acres.

„ I. Overwood (1 to 5 years old) $\frac{5 \times 100}{40} = 12\frac{1}{2}$ acres.

„ II. Underwood (trees 6 to 10 years) $10 \times 5 = 50$ acres.

„ II. Overwood „ „ $2\frac{1}{2} \times 5 = 12\frac{1}{2}$ acres.

And so on, for remaining overwood-classes.

Four classes of the overwood occupy the same area as one of the underwood, so that by taking the area of the latter as the area of one age-class, there would be

I. Class.

Underwood—	50 acres	with trees	1-5	years old.
Overwood—	„	„	1-20	years old.

II. Class.

Underwood—	50 acres	with trees	6-10	years old.
Overwood—	„	„	21-40	years old.

On every coupe of the underwood, all classes of the overwood are represented in equal proportions.

The number of gradations of age in the overwood is generally taken as $\frac{mr}{r} - 1$, when *mr* is the revolution of the standards, *r* that of the coppice. The first class is then supposed to belong to the coppice, being of the same age as, and undistinguishable from, it.

CHAPTER VI.

QUANTITY OF STANDING STOCK IN A MODEL-FOREST.

A.—Clean Cuttings.

The quantity of standing stock in a model-forest, may be determined, (1) by means of tables showing the quantity of produce on a unit of surface for all ages of the trees, and by (2) the method known as the method of mean yearly growth.

(1). By Experiential Tables.

In practice it would involve too much labour to determine by direct experiment the contents of groups of all ages, even if such a thing were possible; it is necessary, therefore, when preparing tables, to be content with a determination of the contents of groups of different ages, at regular intervals, neglecting, for the moment, intervening groups whose contents are afterwards approximately ascertained by interpolation.

In the Table of Yields, at page 6, the contents of groups at intervals of ten years in age are shown. To find the contents of the intermediate groups in the series, we may proceed as follows:—Let a represent the quantity of material on a unit of surface for a group n years old, b the same for a group $2n$ years old, c that of a group $3n$ years old, d that of a group $4n$ years old. We shall then have for a model-forest, with a revolution of $4 \times n$ years, and immediately before a cutting:—

n compartments with groups 0 to n years old, of mass 0 to a, and exclusive of a, or a total contents $(0 + a)\frac{n+1}{2}$* $- a$

n	,,	,,	,,	n to $2n$	,,	,, a to b,	,,	b,	,,	$(a + b)\frac{n+1}{2} - b$
n	,,	,,	,,	$2n$ to $3n$	,,	,, b to c,	,,	c,	,,	$(b + c)\frac{n+1}{2} - c$
n	,,	,,	,,	$3n$ to $4n$	,,	,, c to d, and including		d,	,,	$(c + d)\frac{n+1}{2}$

The sum of these series is

$$\frac{n+1}{2}(0 + 2a + 2b + 2c + d) - (a + b + c)$$

$$= (n + 1)\left(a + b + c + \frac{d}{2}\right) - (a + b + c)$$

$$= n\left(a + b + c + \frac{d}{2}\right) + \frac{d}{2}.$$

Immediately after a cutting the sum of the series would be:—

$$\frac{n+1}{2}(0 + 2a + 2b + 2c + d) - (a + b + c + d)$$

$$= n\left(a + b + c + \frac{d}{2}\right) - \frac{d}{2}$$

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* *I.E.*, by inserting an arithmetical series for the intermediate groups. The formula for finding the sum of an arithmetical series is $s = (a + l)\frac{n}{2}$, when s = the sum, a the first term, l the last term, and n the number of terms.

the revolution; the cutting commencing $\frac{m}{2}$ years before and ending $\frac{m}{2}$ years after the term fixed. The supply may then be estimated in the same way as for clean cuttings. Otherwise, the quantity of material in the series 1 to r (or 0 to $r - 1$) years old is taken, and added to the surplus of the regeneration-class (see also p. 32). Let a be the quantity of material of a group, r years old on a unit of surface, b that of a group $r + m$ years old, and m the period required for regeneration. The material constituting a series of groups of ages r to $r + m$ would be $\frac{m}{2}$ $(a + b)$. This would be the formula for finding the contents of m *completely stocked* groups in an arithmetical series. But—as we may assume that the same quantity is, on an average, removed every year from the regeneration-class—the quantity of standing stock, in the present case, will be only half this amount, or

$$\frac{\frac{m}{2}(a+b)}{2} = \frac{m}{4}(a+b).$$

Example.—For a revolution of ninety years when $m = 10$, and the returns are those shown in the table, p. 6.

Here $a = 1247$. $b = 1363$. The surplus of the regeneration-class is, therefore, $\frac{10}{4}$ $(1247 + 1363) = 6525$ cubic feet.

Hence, the supply in the normal* forest would be

$$10\left(40 + 87 + 232 + 406 + 580 + 783 + 957 + 1102 + \frac{1247}{2}\right) - \frac{1247}{2} + 6525 = 54006\tfrac{1}{2} \text{ cubic feet.}$$

II. *Coppice.*

This is estimated in the same way as seedling forest with clean cuttings.

* The term *normal* is used in the same sense as *ideal.*

III. *Overwood.*

Overwood may, as we have seen in the chapter on age-classes, be regarded in the light of open seedling-forest occupying the whole area without reference to the underwood.

The size of a coupe of standards in the model-forest is theoretically $\frac{A}{mr}$, when the revolution of the overwood is *mr*, and, if each age-class is considered as occupying a piece of land by itself, there will be *mr* groups in a regular series from 1 to *mr* years old, each occupying a space $\frac{A}{mr}$. If, now, we know the degree of density of a forest, we may easily determine the quantity of standing stock; for, if the fully-stocked forest is taken as the unit of comparison and the density of the overwood as a constant fraction of it, all that has to be done is to multiply the supply of the fully-stocked forest by such fraction.

A knowledge of the quantity of standing stock of overwood required for a model forest will not, however, be of any use in organising a forest unless it leads to a determination of the number of trees of every age which should go to make up the sum total, because trees of all ages are found on the same coupe in a confused mass, and the area they occupy cannot be measured for each single tree. For practical purposes, what has to be decided is the number of trees of each age-class of a series to be permanently maintained. This cannot be ascertained accurately, but it is possible to obtain a more or less correct estimate, which may serve as a guide. The first thing to do is to determine the area of the annual cutting. This, as we have seen, is $\frac{A}{mr}$. The degree of density has then to be decided

on sylvicultural principles, with reference to the species concerned, station, and so forth, and may be given in decimals, full density being equal to 1. Next to be determined is the cover of each tree of a class, *i.e.*, the area occupied by it. This may be found by measuring the area occupied by a number of trees of the mean age required and striking an average. The area occupied by a tree is found by measuring the area enclosed by (imaginary) perpendicular lines dropped from the tips of the outermost branches. If s_1, s_2, s_3, etc., represent the surfaces taken up by sample trees of the 1st, 2nd, and 3rd classes respectively, q the degree of density of the overwood, and $n\frac{A}{mr}$ the area of an age-class, the number of trees in each class will evidently be :—

$$\text{Class I. } \frac{n\frac{A}{mr}}{s_1} \times q.; \quad \text{Class II. } \frac{n\frac{A}{mr}}{s_2} \times q.; \quad \text{Class III. } \frac{n\frac{A}{mr}}{s_3} \times q$$

and so on.

Supposing we have a model forest of overwood, 120 acres in extent, with a revolution of sixty years : $q = \cdot25$: age-classes proceeding by differences of ten years : and that the following average values have been obtained of s_1, s_2, &c. :—

$s_1 = 3$ square yards ; $s_2 = 6$ square yards ; $s_3 = 10$ square yards.
$s_4 = 16$ square yards ; $s_5 = 25$ square yards ; $s_6 = 36$ square yards.

The yearly cutting will be $\frac{120}{60} =$ acres $= 9{,}680$ square yards.

Each class will occupy 20 acres. The number of trees in each class will be as follows :—

Class I. (1 to 10 years old) $= 10 \times \frac{9680}{3} \times \cdot25 = 8067$

Class II. (11 to 20 years) $= 10 \times \frac{9680}{6} \times \cdot25 = 4034$

Class III. (21 to 30 years) $= 10 \times \frac{9680}{10} \times \cdot25 = 2420$

Class IV. (31 to 40 years) $= 10 \times \frac{9680}{16} \times \cdot25 = 1513$

$$\text{Class V. (41 to 50 years)} = 10 \times \frac{9680}{25} \times \cdot 25 = 968$$

$$\text{Class VI. (51 to 60 years)} = 10 \times \frac{9680}{36} \times \cdot 25 = 672.$$

This represents the quantity of standing stock immediately before cutting. On each coupe of the underwood there will be trees representing each age-class of the overwood, each class occupying an equal area. If, in the above example, the revolution of the underwood were ten years, its annual coupe would be $\frac{120}{10} = 12$ acres, and on the oldest, just before a cutting, there would be overwood 60, 50, 40, 30, 20, 10 years old, each class occupying two acres of land. The next in order would have overwood 59, 49, 39, 29, 19, 9 years old, and so on in regular succession down to the youngest with overwood 50, 40, 30, 20, 10, 1 years old. Each underwood-coupe would have 807 first-class standards, 403 of the second, 242 of the third, 151 of the fourth, 97 of the fifth, and 67 of the sixth class. On the oldest coupe, for example, there would be 807 standards ten years old, 403 twenty, 242 thirty, 151 forty, 97 fifty, and 67 sixty years old; the annual yield being 404 of the first class (virtually belonging to the coppice), 161 of the second, 91 of the third, 54 of the fourth, 30 of the fifth, and 67 of the sixth class.

The contents of the average sample tree for each class being known, it is, of course, easy to estimate the contents of the standing stock.

If, for instance, the sample trees in the above example contained on an average 0·02 cubic feet for Class I., ·2 cubic feet for Class II., ·75 cubic feet for Class III., 1·7 c.f. for Class IV., 3·2 c.f. for Class V., and 5 c.f. for Class VI., the supply of overwood would amount to

$$8067 \times \cdot 02 + 4034 \times \cdot 2 + 2420 \times \cdot 75 + 1513 \times 1{\cdot}7 + 968 \times 3{\cdot}2 + 672 \times 5$$
$$= 11812{\cdot}84 \text{ cubic feet.}$$

to the cost of cultivation, if the prospective-value is taken as the value of the land. For,

$$H_m = \frac{H_r + D_a 1{\cdot}0p^{r-a} + \dots + D_n 1{\cdot}0p^{r-n} - (B+V)(1{\cdot}0p^r - 1)}{1{\cdot}0p^r}$$

Substituting the prospective-value for B in the above, we get,

$$H_m = \frac{H_r + D_a 1{\cdot}0p^{r-a} + \dots + D_n 1{\cdot}0p^{r-n} - \left(\frac{H_r + D_a 1{\cdot}0p^{r-a} + \dots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V + V\right)(1{\cdot}0p^r - 1)}{1{\cdot}0p^r}$$

$$= \frac{c\,1{\cdot}0p^r}{1{\cdot}0p^r} = c.$$

(2). *The Cost-Value*

Of an isolated group m years old is found by deducting all receipts from all expenditure up to the year m.

The expenditure will have been

1. The interest on the purchase money of the land for m years, or

$$B\,1{\cdot}0p^m - B = B\,(1{\cdot}0p^m - 1)$$

2. The cost of cultivation, with interest,

$$= c\;1{\cdot}0p^m$$

3. The interest on capital representing the yearly charges,

$$= V\,(1{\cdot}0p^m - 1)$$

The receipts will consist in any thinnings which may have been received previous to the mth year. These will be worth, in the mth year,

$$D_a \, 1{\cdot}0\,p^{m-a},\; D_b \, 1{\cdot}0\,p^{m-b},\; \&c.$$

Therefore,

$$H_m = (B+V)\,(1{\cdot}0\,p^m - 1) + c\,1{\cdot}0\,p^m - (D_a\,1{\cdot}0\,p^{m-a} + \ldots + D_n\,1{\cdot}0\,p^{m-n})$$

Example.—What is the cost-price of a group 40 years old, calculating interest at the rate of 3 per cent., the value of the land at 166·6*s.*, and other items of receipts and expenditure as in the Table at page 6?

$$\text{Here,} \quad B = 166{\cdot}6 \quad : \quad V = \frac{2}{0{\cdot}03} = 66{\cdot}7$$

$$c = 10 \quad : \quad D_{30} = 13{\cdot}5$$

$$\therefore H_{40} = (166{\cdot}6 + 66{\cdot}7)\;(1{\cdot}03^{40} - 1) + 10 \times 1{\cdot}03^{40} - 13{\cdot}5 \times 1{\cdot}03^{10}$$
$$= 542s.$$

At the commencement of the revolution the cost-value is equal to the cost of cultivation. For it is,

$$(B + V)\;(1{\cdot}0\,p^0 - 1) + c\,1{\cdot}0\,p^0 = c.$$

At the end of the revolution, if the price of the land was its prospective value, the value of the group is H_r. For,

$$H_m = (B + V)\;(1.0\,p^r - 1) + c1{\cdot}0\,p^r - (D_a\,1{\cdot}0\,p^{r-a} + \cdots + D_n 1{\cdot}0\,p^{r-n})$$

Substituting for B its prospective value, we get,

$$H_m = \left(\frac{H_r + D_a 1{\cdot}0p^{r-a} + \ldots\ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V + V\right)\left(1{\cdot}0p^r - 1\right) + c\,1{\cdot}0p^r$$
$$- \left(D_a 1{\cdot}0p^{r-a} + \ldots\ldots + D_n 1{\cdot}0p^{r-n}\right) = H_r.$$

(3). *The Market-value* of a group may be ascertained by actual sale, or from records of recent sales of forest, similar as regards quality and situation to that whose value is to be found.

II.—The Model Forest.

(1). *The Prospective value* of a model forest immediately after a cutting will be as follows. There will be r groups from 0 to $r - 1$ years old, and—

$\frac{H_r - (B+V)(1{\cdot}0p - 1)}{1{\cdot}0p}$ . . . . will be the prospective value of the group $r - 1$ years old.

$\frac{H_r - (B+V)(1{\cdot}0p^2) - 1)}{1{\cdot}0p^2}$ . . . . ditto ditto of the group $r - 2$ years old.

⋮

$\frac{H_r - (B+V)(1{\cdot}0p^{r-n} - 1)}{1{\cdot}0p^{r-n}}$ . . . . ditto ditto of the group n years old.

⋮

$\frac{H_r + D_n 1{\cdot}0p^{r-n} - (B+V)(1{\cdot}0p^{r-(n-1)} - 1)}{1{\cdot}0p^{r-(n-1)}}$ ditto ditto of the group $n - 1$ years old.

⋮

$\frac{H_r + D_n 1{\cdot}0p^{r-n} - (B+V)(1{\cdot}0p^{r-0} - 1)}{1{\cdot}0p^{r-0}}$ ditto ditto of the group 0 years old.

Hence the sum is:

$$H_r\left(\frac{1}{1{\cdot}0p}+\frac{1}{1{\cdot}0p^2}+\cdots\cdots+\frac{1}{1{\cdot}0p^r}\right)-(B+V)\left(\frac{1{\cdot}0p}{1{\cdot}0p}+\frac{1{\cdot}0p^2}{1{\cdot}0p^2}+\cdots\cdots+\frac{1{\cdot}0p^r}{1{\cdot}0p^r}\right)+(B+V)\left(\frac{1}{1{\cdot}0p}+\frac{1}{1{\cdot}0p^2}\right.$$

$$\left.+\cdots+\frac{1}{1{\cdot}0p^r}\right)+D_n 1{\cdot}0p^{r-n}\left(\frac{1}{1{\cdot}0p^{r-(n-1)}}+\frac{1}{1{\cdot}0p^{r-(n-2)}}+\cdots\cdots+\frac{1}{1{\cdot}0p^{r-(n-n)}}\right)$$

$$=\frac{H_r(1{\cdot}0p^r-1)}{1{\cdot}0p^r\times 0{\cdot}0p}-r(B+V)+\frac{D_n 1{\cdot}0p^{r-n}(1{\cdot}0p^n-1)}{1{\cdot}0p^r\times 0{\cdot}0p}+\frac{(B+V)(1{\cdot}0p^r-1)}{1{\cdot}0p^r\times 0{\cdot}0p}$$ (see formula B, p. 11).

Similarly, any other intermediate cuttings D_a, D_b, &c., in the years a, b, &c., will appear in the formula as—

$$+\frac{D_a 1{\cdot}0p^{r-a}(1{\cdot}0p^a-1)}{1{\cdot}0p^r\times 0{\cdot}0p}+\frac{D_b 1{\cdot}0p^{r-b}(1{\cdot}0p^b-1)}{1{\cdot}0p^r\times 0{\cdot}0p}+\text{\&c.}$$

Therefore the sum—

$$S=\frac{(H_r+B+V)(1{\cdot}0p^r-1)+D_a 1{\cdot}0p^{r-a}(1{\cdot}0p^a-1)+\cdots\cdots+D_n 1{\cdot}0p^{r-n}(1{\cdot}0p^n-1)}{1{\cdot}0p^r\times 0{\cdot}0p}-r(B+V)$$

Example.—What is the prospective value of the standing stock of a model forest subject to a revolution of fifty years, with receipts and expenditure per unit, as shown in the Table, page 6, when $p=3$?

Here $H_{50} = 533{\cdot}6 + 48{\cdot}8 = 582{\cdot}4 : D_{30} = 13{\cdot}5 : D_{40} = 28{\cdot}08 : V = \frac{2}{0{\cdot}03} = 66{\cdot}67 : B_p = 111$

$$S = \frac{(582{\cdot}4 + 66{\cdot}667 + 111)(1{\cdot}03^{50} - 1) + 13{\cdot}5 \times 1{\cdot}03^{50-30}(1{\cdot}03^{30} - 1) + 28{\cdot}08 \times 1{\cdot}03^{50-40}(1{\cdot}03^{40} - 1)}{1{\cdot}03^{50} \times 0{\cdot}03} - 50\,(111 + 66{\cdot}67)$$

$$= \frac{2572{\cdot}05 + 34{\cdot}801 + 85{\cdot}361}{{\cdot}131517} - 8883{\cdot}5$$

$$= 20470{\cdot}5 - 8883{\cdot}5$$

$$= 11587{\cdot}0.$$

By inserting the prospective value of the land in the above formula, we get

$$S = \left[\left(H_r + \frac{H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V + V\right)(1{\cdot}0p^r - 1) + D_a 1{\cdot}0p^{r-a}(1{\cdot}0p^a - 1) + \ldots\ldots + D_n 1{\cdot}0p^{r-n}(1{\cdot}0p^n - 1)\right] \div 1{\cdot}0p^r \times 0{\cdot}0p - r\,(B_p + V)$$

$$= \frac{H_r(1{\cdot}0p^r - 1) + H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r + D_a 1{\cdot}0p^{r-a}(1{\cdot}0p^a - 1) + \ldots + D_n 1{\cdot}0p^{r-n}(1{\cdot}0p^n - 1)}{1{\cdot}0p^r \times 0{\cdot}0p} - r\,(B_p + V)$$

$$= \frac{H_r 1{\cdot}0p^r - H_r + H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r + D_a 1{\cdot}0p^r - D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^r - D_n 1{\cdot}0p^{r-n}}{1{\cdot}0p^r \times 0{\cdot}0p} - r\,(B_p + V)$$

$$= \frac{H_r 1{\cdot}0p^r + D_a 1{\cdot}0p^r + \ldots + D_n 1{\cdot}0p^r - c\, 1{\cdot}0p^r}{1{\cdot}0p^r \times 0{\cdot}0p} - r(B_p + V)$$

$$= \frac{H_r + D_a + \ldots + D_n' - c}{0{\cdot}0p} - r(B_p + V)$$

And, since $V = \frac{v}{0{\cdot}0p}$,

$$S = \frac{H_r + D_a + \ldots + D_n - c - rv}{0{\cdot}0p} - r.B_p$$

The first term of this expression is identical with the formula for finding the nett rental of an estate (see page 8). We may, therefore, obtain the value of the standing stock by simply capitalizing the nett rental and deducting from the amount the value of the land, that is to say, of r units, always provided that the prospective value is taken as the value of the land.

Example.—For the model forest with a revolution of 90 years, and receipts and expenditure per unit, as shown in the Table, page 6.

Here $B_p = 166{\cdot}7$: $H_{90} = 2494 + 73{\cdot}6 = 2567{\cdot}6$: $c = 10$:

$$
\begin{aligned}
D_{30} &= 13{\cdot}5 \qquad v = 2 \\
D_{40} &= 28{\cdot}1 \\
D_{50} &= 48{\cdot}8 \\
D_{60} &= 53{\cdot}4 \\
D_{70} &= 58{\cdot}2 \\
D_{80} &= 60{\cdot}3 \\
\text{Total} &\quad 262{\cdot}3
\end{aligned}
$$

Therefore value of stock $= \dfrac{2567{\cdot}6 + 262{\cdot}3 - 10 - 90 \times 2}{0{\cdot}03} - 90 \times 166{\cdot}7 = 87997 - 15003 = 72994.$

(2). *The Cost-Value*

of the series of a model forest is found in a similar way to the prospective, only the receipts take a negative sign, the expenditure a positive sign. Thus, immediately before a cutting,

$(B + V)\ (1{\cdot}0p^0 - 1) + c\,1{\cdot}0p^0$ . . . . will be the cost-price of the group 0 years old.

$(B + V)\ (1{\cdot}0p - 1) + c\,1{\cdot}0p$ . . . . ditto ditto of the group 1 year old.

$(B+V)\ (1{\cdot}0p^n-1)+c\,1{\cdot}0p^n-D_n$ . . . . . ditto ditto of the group n years old.

$\vdots$

$(B+V)\ (1{\cdot}0p^{n+1}-1)+c\,1{\cdot}0p^{n+1}-D_n\,1{\cdot}0p$ . . . ditto ditto of the group $n+1$ years old.

$\vdots$

$(B+V)\ (1{\cdot}0p^{r-1}-1)+c\,1{\cdot}0p^{r-1}-D_n\,1{\cdot}0p^{r-n-1}$. ditto ditto of the group $r-1$ years old.

The sum of the above series is

$$(B+V)\ (1{\cdot}0\,p^0+1{\cdot}0\,p+\ldots+1{\cdot}0\,p^{r-1})-r(B+V)+c(1{\cdot}0\,p^0+1{\cdot}0\,p+\ldots+1{\cdot}0\,p^{r-1})-D_n(1+1{\cdot}0\,p+\ldots+1{\cdot}0\,p^{r-n-1})$$
$$=\frac{(B+V)\ (1{\cdot}0\,p^r-1)}{0{\cdot}0\,p}-r\,(B+V)+\frac{c\,(1{\cdot}0\,p^r-1)}{0{\cdot}0\,p}-\frac{D_n\,(1{\cdot}0\,p^{r-n}-1)}{0{\cdot}0\,p}.$$

If any further thinnings are obtained in the years a, b, their values must be inserted in the formula as

$$-\frac{D_a\,(1{\cdot}0\,p^{r-a}-1)}{0{\cdot}0\,p},-\frac{D_b\,(1{\cdot}0\,p^{r-b}-1)}{0{\cdot}0\,p}.$$

Hence, the general formula for finding the cost-value of a series is

$$\frac{(B+V+c)\ (1{\cdot}0\,p^r-1)-[D_a\,(1{\cdot}0\,p^{r-a}-1)+\ldots.+D_n\,(1{\cdot}0\,p^{r-n}-1)]}{0{\cdot}0\,p}-r\,(B+V).$$

Example.—For a series subject to a revolution of 40 years, and with receipts and expenditure per unit as shown in the Table, page 6. Value of the land 111*s*., and $p=3$.

Here $V=66{\cdot}7\ :\ c=10\ :\ D_{30}=13{\cdot}5$

Therefore,

$$\text{Value of Series} = \frac{(111 + 66{\cdot}7 + 10)\,(1{\cdot}03^{40} - 1) - (13{\cdot}5 \times 1{\cdot}03^{10} - 1)}{0{\cdot}03} - 40\,(111 + 66{\cdot}7)$$

$$= 13997{\cdot}8 - 7108$$

$$= 6889{\cdot}8.$$

If, in the formula for the cost-value of a series, we put, for B, the prospective value of the land, we get

$$\frac{\left(\frac{H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V + V + c\right)(1{\cdot}0p^r - 1) - [D_a(1{\cdot}0p^{r-a} - 1) + \ldots + D_n(1{\cdot}0p^{r-n} - 1)]}{0{\cdot}0p} - r(B_p + V)$$

$$= \frac{H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r + c\,1{\cdot}0p^r - c - [(D_a 1{\cdot}0p^{r-a} - D_a) + \ldots + (D_n 1{\cdot}0p^{r-n} - D_n)]}{0{\cdot}0p} - r(B_p + V)$$

$$= \frac{H_r + D_a + \ldots + D_n - c}{0{\cdot}0p} - r(B_p + V)$$

And since $V = \frac{v}{0{\cdot}0p}$

$$= \frac{H_r + D_a + \ldots + D_n - c - rv}{0{\cdot}0p} - r(B_p)$$

That is to say, if the prospective value is taken as the value of the land, the value of the standing stock of a series is found by capitalising the nett rental of the estate, and deducting the value of the land from the result.

Whenever, therefore, the prospective value of the land is employed in estimating the value of a series, the cost-value and prospective value of the standing stock are identical. (See also page 50.)

RELATION OF THE COST-VALUE OF A GROUP TO ITS MARKET-VALUE WHEN THE VALUE OF THE LAND IS THE MAXIMUM PROSPECTIVE VALUE.

If the market-value and cost-value of a group were equal for every age, the prospective-value of the land would evidently be the same for all revolutions. Since, however, a maximum prospective-value of the land is obtainable for a certain revolution while the cost-value yields a uniform percentage on outlay equal to that afforded by the group if cut at the end of the financial revolution (see page 68) it follows that H_c is greater than H_m before and after the end of the financial revolution. That, under these conditions, $H_m = H_c$ at the end of the revolution, we have already seen (pages 50 and 54).

CHAPTER VIII.

VALUE OF AN ESTATE.

The value of an estate consists in the value of the land, plus the value of the standing-stock.* It may be estimated according to its

1. Prospective-Value,
2. Cost-Value,
3. Market-Value,

and also, but only in the case of a complete series, according to its

4. Rental-Value.

(1). The Prospective-Value.

For a compartment, (B), and group, (H), this will amount to the prospective value of the standing stock, plus the value of the land, (B); or, if the group is m years old, to

$$\frac{H_r + D_a\, 1{\cdot}0\,p^{r-a} + \ldots\ldots + D_n\, 1{\cdot}0\,p^{r-n} - (B+V)\,(1{\cdot}0\,p^{r-m} - 1)}{1{\cdot}0\,p^{r-m}} + B$$

(See page 44).

$$= \frac{H_r + D_a\, 1{\cdot}0\,p^{r-a} + \ldots\ldots + D_n\, 1{\cdot}0\,p^{r-n} - V\,(1{\cdot}0\,p^{r-m} - 1) + B}{1{\cdot}0\,p^{r-m}}$$

---

* Not necessarily the value of a series and the land on which stands. Unless there is an express statement to the contrary, w follows refers to single groups.

Example.—For a compartment with group 40 years old, and receipts and expenditure as shown in the Table, and for a revolution of 50 years. Interest 3 per cent., and $B = 111$.

$$H_{50} = 533{\cdot}6 + 48{\cdot}8 = 582{\cdot}4$$

$$D_{30} = 13{\cdot}5 \ : \ D_{40} = 28{\cdot}1 \ : \ V = \frac{2}{0{\cdot}03} = 66{\cdot}67$$

$$B = 111.$$

Value of Estate

$$= \frac{582{\cdot}4 + 13{\cdot}5 \times 1{\cdot}03^{20} + 28{\cdot}1 \times 1{\cdot}03^{10} - 66{\cdot}67(1{\cdot}03^{10} - 1) + 111}{1{\cdot}03^{10}}$$

$$= \frac{582{\cdot}4 + 24{\cdot}38 + 37{\cdot}77 - 22{\cdot}93 + 111}{1{\cdot}344}$$

$$= 545s.$$

(2). Cost-Value.

This will be for a compartment with group m years old :—

$$(B + V)(1{\cdot}0p^m - 1) + c\ 1{\cdot}0p^m - (D_a 1{\cdot}0p^{m-a} + \dots + D_n 1{\cdot}0p^{m-n}) + B$$

(see page 46),

$$= (B + V + c)\ 1{\cdot}0p^m - (D_a\ 1{\cdot}0\ p^{m-a} + \dots + D_n\ 1{\cdot}0\ p^{m-n} + V).$$

If in the above formula the prospective-value is taken as the value of the land, and substituted for B, and if D_a denotes the value in the year a of the sum of all thinnings received previous to the year m, and D_n the value in the year n of the sum of those received after the year m, the formula becomes

$$\left(\frac{H_r + D_a 1{\cdot}0p^{r-a} + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V + V + c\right) 1{\cdot}0p^m - (D_a 1{\cdot}0p^{m-a} + V)$$

$$= \frac{[H_r + D_a 1{\cdot}0p^{r-a} + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r + c(1{\cdot}0p^r - 1)]\,1{\cdot}0p^m - D_a 1{\cdot}0p^{m-a}(1{\cdot}0p^r - 1)}{1{\cdot}0p^r - 1} - V$$

$$= \frac{(H_r + D_a 1{\cdot}0p^{r-a} + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r + c\,1{\cdot}0p^r - c)\,1{\cdot}0p^m - (D_a 1{\cdot}0p^{r-a} + D_a 1{\cdot}0p^{-a})\,1{\cdot}0p^m}{1{\cdot}0p^r - 1} - V$$

$$= \frac{(H_r + D_a 1{\cdot}0p^{-a} + D_a 1{\cdot}0p^{r-a} - D_a 1{\cdot}0p^{r-a} + D_n 1{\cdot}0p^{r-n} - c)\,1{\cdot}0p^m}{1{\cdot}0p^r - 1} - V$$

$$= \frac{(H_r + D_a 1{\cdot}0p^{-a} + D_n 1{\cdot}0p^{r-n} - c)\,1{\cdot}0p^m}{1{\cdot}0p^r - 1} - V$$

The same result is obtained by substituting for B the prospective value of the land in the formula for the prospective-value of an estate. If, therefore, B_p is taken as the value of the land, the cost-value and prospective-value of an estate are identical.

(3). Market-Value.

This may be determined by actual sale or from records of recent sales of estates similar as regards quality and situation.

(4). Rental-Value.

For the isolated compartment and group there is a periodical, but not a yearly, rent, and we cannot, therefore, find its rent-value. It is true that we may find

the present value of all receipts, less that of all expenditure, convert the amount into a yearly rent, and then the yearly rent back into the sum previously obtained, but this would still not be obtaining the value of the estate from the rent, but the converse.

The rent-value of an estate with a complete series is obviously equal to the capitalized value of the receipts after deducting all expenditure, or

$$\frac{H_r + D_a + \dots + D_n - c - rv.}{0{\cdot}0\,p.}$$

CHAPTER IX.

THE CAPABILITY.

This term, which is synonymous with *possibility* and *sustained yield*, is used to denote the yearly quantity of wood, or its equivalent in money, which a series is capable of yielding for a given revolution without the capital-stock of the forest being trenched upon.

(1). Yield of Material.

In the simplest case of the model forest with clean cuttings, the annual yield is, as we have seen in Chapter I., equal to the oldest group, occupying an area $\frac{A}{r}$ (or $\frac{A}{r+n}$, as the case may be).

In the case of a model forest subject to natural regeneration by seed, the yield is the same as for forests with clean cuttings, provided that cuttings commence $\frac{m}{2}$ years before the end of the revolution fixed, when m is the term required for regeneration and the trees are removed in equal quantities at regular intervals. The average age of the trees is then r years, as in the case of clean cuttings.

(2). Money Yield.

An estate consisting of an isolated compartment and group can, of course, yield a rent only once during a revolution, and has, therefore, strictly speaking, no sustained yield. It is, however, sometimes desirable

to know the yearly rent which is equivalent to a given periodical rent. At page 19 we found that the prospective value of an unstocked estate, capable of yielding a return every r years, is

$$\frac{H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V$$

This sum would yield a yearly rental of

$$\left(\frac{H_r + D_a 1{\cdot}0p^{r-a} + \ldots + D_n 1{\cdot}0p^{r-n} - c\,1{\cdot}0p^r}{1{\cdot}0p^r - 1} - V\right) 0{\cdot}0p$$

which may be regarded as a sustained yield, although, of course, it cannot be realized regularly every year.

The sustained yield of an estate with a complete series is, as was shown at page 9,

$$H_r + D_a + \quad \ldots \quad + D_n - c - vr.$$

CHAPTER X.—BALANCING.

THE PRODUCTIVE CAPITAL,

Or *capital-outlay,* is a term used to denote the capital employed in producing, or necessary to produce, a given rental.

THE CURRENT RETURN PER CENT. ON OUTLAY.

This is the return in any given year, m. For the isolated compartment and group, the capital-outlay up to any year, m, is evidently

$$(B + V + c)\,1{\cdot}0p^{m} - (D_a 1{\cdot}0\,p^{m-a} + \ldots + D_n 1{\cdot}0\,p^{m-n})$$
$$= [(B + V + c) - (D_a 1{\cdot}0\,p^{-a} + \ldots + D_n 1{\cdot}0\,p^{-n})]\,1{\cdot}0\,p^{m}$$

If, now, H_m is the value of the yield in the year m, H_{m+1} that of the yield in the year $m + 1$, the return per cent., p', will be found [since the capital-outlay is to $(H_{m+1} - H_m)$ as 100 is to p'] by the equation

$$p' = \frac{(H_{m+1} - H_m)\,100}{[B + V + c - (D_a 1{\cdot}0\,p^{-a} + \ldots + D_n{}^{-n})]\,1\,0p^{m}}$$

By adding to the denominator $B + V - (B + V)$ its value is not altered, and it becomes

$$[B + V + c - (D_a 1{\cdot}0\,p^{-a} + \ldots + D_n 1{\cdot}0\,p^{-n})]\,1{\cdot}0\,p^{m} + B + V - (B + V)$$
$$= (B + V)(1{\cdot}0\,p^{m} - 1) + c\,1{\cdot}0\,p^{m} - (D_a 1{\cdot}0\,p^{m-a} + \ldots$$
$$\ldots + D_n 1{\cdot}0\,p^{m-n}) + B + V$$

$= H_c + B + V$ **when** H_c **= cost-value of the standing stock** m **years old.**

Therefore $$p' = \frac{(H_{m+1} - H_m)100}{H_c + B + V}$$

Example.—The value of a group fifty years old is 582·4 shillings; that of the same group when fifty-one years old 610·9 shillings. The other receipts or expenditure incurred are the same as those shown in the table for a group fifty years old. What will be the current return on outlay if the group is cut when fifty-one years old?

Here $B = 111;\ V = \frac{2}{0\cdot03} = 66\cdot67;\ c = 10;\ p = 3.$

$$H_e = (111 + 66\cdot67)(1\cdot03^{50} - 1) + 10 \times 1\cdot03^{50} - (13\cdot5 \times 1\cdot03^{20} + 28\cdot1 \times 1\cdot03^{10})$$

$$= 601\cdot22 + 43\cdot84 - (24\cdot38 + 37\cdot77).$$

$$= 582\cdot9.$$

Therefore $$p' = \frac{(610\cdot9 - 582\cdot4)\ 100}{582\cdot9 + 111 + 66\cdot67} = \frac{2850}{760\cdot57} = 3\cdot7.$$

IF THE MAXIMUM PROSPECTIVE VALUE IS TAKEN AS THE VALUE OF THE LAND, p' IS GREATER THAN p BEFORE THE END OF THE FINANCIAL REVOLUTION, BUT SMALLER AFTERWARDS.

For the year r to $r + 1$,

$$p' = \frac{(H_{r+1} - H_r)\ 100}{[B + V + c - (D_a\ 1\cdot0p^{-a} + \ldots + D_n\ 1\cdot0p^{-n})]\ 1\cdot0p^r}$$

And for the year $r - 1$ to r,

$$p' = \frac{(H_r - H_{r-1})\ 100}{[B + V + c - (D_a\ 1\cdot0p^{-a} + \ldots + D_n\ 1\cdot0p^{-n})]\ 1\cdot0p^{r-1}}$$

Now, it can be shown that p' will be equal to p if H_{r-1}, H_r, and H_{r+1} are equal to their respective cost-values. For, in that case, we would have for the numerator of the former equation:

$$\begin{aligned} H_{r+1} - H_r = {} & (B+V)(1{\cdot}0\,p^{r+1} - 1) + c\,1{\cdot}0\,p^{r+1} - (D_a\,1{\cdot}0\,p^{r+1-a} + \ldots + D_n\,1{\cdot}0\,p^{r+1-n}) \\ & - [(B+V)(1{\cdot}0\,p^{r} - 1) + c\,1{\cdot}0\,p^{r} - (D_a\,1{\cdot}0\,p^{r-a} + \ldots + D_n\,1{\cdot}0\,p^{r-n})] \\ = {} & B\,1{\cdot}0\,p^r \times 1{\cdot}0\,p - B\,1{\cdot}0\,p^r + V\,1{\cdot}0\,p^r \times 1{\cdot}0\,p - V\,1{\cdot}0\,p^r + c\,1{\cdot}0\,p^r \times 1{\cdot}0\,p - c\,1{\cdot}0\,p^r \\ & - [(D_a\,1{\cdot}0\,p^{r-a} \times 1{\cdot}0\,p - D_a\,1{\cdot}0\,p^{r-a}) + \ldots + (D_n\,1{\cdot}0\,p^{r-n} \times 1{\cdot}0\,p - D_n\,1{\cdot}0\,p^{r-n})] \\ = {} & B\,1{\cdot}0\,p^r(1{\cdot}0\,p - 1) + V\,1{\cdot}0\,p^r(1{\cdot}0\,p - 1) + c\,1{\cdot}0\,p^r(1{\cdot}0\,p - 1) \\ & - [(D_a\,1{\cdot}0\,p^{r-a})(1{\cdot}0\,p - 1) + \ldots + (D_n\,1{\cdot}0\,p^{r-n})(1{\cdot}0\,p - 1)] \\ = {} & [B + V + c - (D_a\,1{\cdot}0\,p^{-a} + \ldots + D_n\,1{\cdot}0\,p^{-n})]\,1{\cdot}0\,p^r \times 0{\cdot}0\,p \end{aligned}$$

Therefore,

$$p' = \frac{[B + V + c - (D_a\,1{\cdot}0\,p^{-a} + \ldots + D_n\,1{\cdot}0\,p^{-n})]\,1{\cdot}0\,p^r \times 0{\cdot}0\,p \times 100}{[B + V + c - (D_a\,1{\cdot}0\,p^{-a} + \ldots + D_n\,1{\cdot}0\,p^{-n})]\,1{\cdot}0\,p^r} = p.$$

Similarly, it will be found that under the same conditions for the year $r-1$ to r, $p' = p$. But since, in reality, only $H_r = H_c$, and H_{r+1} and H_{r-1} are smaller than their corresponding cost-values (see p. 55), it follows that p' is greater than p in the year $(r-1)$ to r, but smaller in the year r to $(r+1)$.

The Average Yearly Return on the Capital-Outlay.

1. *The Isolated Compartment.*

To find this return we must divide the average gross receipts per annum by the capital-outlay, and multiply the result by 100. The average gross receipts per annum will be

$$\left(\frac{H_r + D_a\, 1{\cdot}0p^{r-a} + \dots + D_n\, 1{\cdot}0p^{r-n}}{1{\cdot}0p^r - 1}\right) 0{\cdot}0p$$ (See p. 60.)

This, it should be noted, represents the average gross income, not for a limited period, but for ever. The cost of cultivation must, therefore, be taken, not as a single charge, but as a capital producing every r years the sum required for that purpose. The capital-outlay will, therefore, be

$$B + V + \frac{c\, 1{\cdot}0p^r}{1{\cdot}0p^r - 1}$$

and the return per cent. on it will be

$$\frac{\dfrac{(H_r + D_a\, 1{\cdot}0p^{r-a} + \dots + D_n\, 1{\cdot}0p^{r-n})\, 0{\cdot}0p \times 100}{1{\cdot}0p^r - 1}}{B + V + \dfrac{c\, 1{\cdot}0p^r}{1{\cdot}0p^r - 1}}$$

$$= \frac{\left(\dfrac{H_r + D_a\, 1{\cdot}0p^{r-a} + \dots + D_n\, 1{\cdot}0p^{r-n}}{1{\cdot}0p^r - 1}\right) p}{B + V + \dfrac{c\, 1{\cdot}0p^r}{1{\cdot}0p^r - 1}}$$

Example.—**For a compartment to be stocked with group subject to a revolution of 50 years, with receipts and expenditure as shown**

in the table, the value of the land being the prospective-value for a revolution of 50 years.

Here $H_{50} = 533{\cdot}6 + 48{\cdot}8 = 582{\cdot}4$;
$D_{30} = 13{\cdot}5$; $D_{40} = 28{\cdot}08$; $p = 3$;
$B = 111$; $V = \dfrac{2}{0{\cdot}03} = 66{\cdot}67$; $c = 10.$

Therefore, the mean yearly return,

$$Y = \frac{\left(\dfrac{582 + 13{\cdot}5 \times 1{\cdot}03^{20} + 28{\cdot}08 \times 1{\cdot}03^{10}}{1{\cdot}03^{50} - 1}\right)3}{111 + 66{\cdot}67 + \dfrac{10 \times 1{\cdot}03^{50}}{1{\cdot}03^{50} - 1}}$$

$$= \frac{\left(\dfrac{582{\cdot}4 + 24{\cdot}38 + 37{\cdot}737}{3{\cdot}3839}\right)3}{111 + 66{\cdot}67 + 12{\cdot}95}$$

$$= \frac{190{\cdot}5 \times 3}{190{\cdot}6} = 3.$$

2. *The Series.*

In this case, the yearly gross receipts are $H_r + D_a + \ldots + D_n$, and if the value of the standing stock is S, the productive capital of the series will be

$$rB + rV + S + \frac{c}{0{\cdot}0\,p}$$

Substituting for S its cost value, we get

$$rB + rV + \frac{(B+V+c)\,(1{\cdot}0\,p^r-1)-[D_a(1{\cdot}0\,p^{r-a}-1)+\ldots+D_n(1{\cdot}0\,p^{r-n}-1)]}{0{\cdot}0\,p} - r\,(B+V)+\frac{c}{0{\cdot}0\,p}$$ (See p. 52).

$$= \frac{0{\cdot}0\,p\,(rB+rV)+(B+V+c)\,(1{\cdot}0\,p^r-1)-[D_a(1{\cdot}0\,p^{r-a}-1)+\ldots+D_n(1{\cdot}0\,p^{r-n}-1)]-0{\cdot}0\,p\,(rB+rV)+c}{0{\cdot}0\,p}$$

$$= \frac{\left(B+V+\frac{c\,1{\cdot}0\,p^r}{1{\cdot}0\,p^r-1}\right)(1{\cdot}0\,p^r-1)-[D_a(1{\cdot}0\,p^{r-a}-1)+\ldots\ldots+D_n(1{\cdot}0\,p^{r-n}-1)]}{0{\cdot}0\,p}$$

The return per cent., p', on the capital-outlay will, therefore, be found by the formula

$$p' = \frac{(H_r+D_a+\ldots\ldots+D_n)\,100}{\dfrac{\left(B+V+\frac{c\,1{\cdot}0\,p^r}{1{\cdot}0\,p^r-1}\right)(1{\cdot}0\,p^r-1)-[D_a(1{\cdot}0\,p^{r-a}-1)+\ldots\ldots+D_n(1{\cdot}0\,p^{r-n}-1)]}{0{\cdot}0\,p}}$$

$$= \frac{(H_r+D_a+\ldots+D_n)\,p}{\left(B+V+\frac{c\,1{\cdot}0\,p^r}{1{\cdot}0\,p^r-1}\right)(1{\cdot}0\,p^r-1)-[D_a(1{\cdot}0\,p^{r-a}-1)+\ldots\ldots+D_n(1{\cdot}0\,p^{r-n}-1)]}$$

Example.—For the series, subject to a revolution of 50 years, and with receipts and expenditure per unit as shown in the Table.

Here

$$H_r = 582{\cdot}4 \;;\; D_{30} = 13{\cdot}5 \;;\; D_{40} = 28{\cdot}08$$
$$B = 111 \;;\; c = 10 \;;\; p = 3 \;;\; V = 66{\cdot}67$$

Therefore,

$$p' = \frac{(582{\cdot}4 + 13{\cdot}5 + 28{\cdot}08)\,3}{\left(111 + 66{\cdot}67 + \dfrac{10 \times 1{\cdot}03^{50}}{1{\cdot}03^{50} - 1}\right)(1{\cdot}03^{50} - 1) - 13{\cdot}5 \times (1{\cdot}03^{20} - 1) - 28{\cdot}08\,(1{\cdot}03^{10} - 1)}$$

$$= \frac{623{\cdot}98 \times 3}{(190{\cdot}23 \times 3{\cdot}3839) - 13{\cdot}5 \times {\cdot}8061 - 28{\cdot}08 \times {\cdot}3439}$$

$$= \frac{1871{\cdot}94}{643{\cdot}72 - 10{\cdot}88 - 9{\cdot}66} = \frac{1871{\cdot}94}{623{\cdot}18.} = 3.$$

The amount of the return on outlay obviously depends on the proportion which the latter bears to gross receipts. The larger the receipts are, and the smaller the productive capital is, the greater will be the return, and *vice versâ*.

If in the formula for finding the average yearly return per cent. on outlay, at page 65, we substitute the prospective-value of the land for B, the return per cent., p',

will be the same as the rate, p, employed in calculating interest on receipts and expenditure. For, as shown above (page 65)—

$$p' = \frac{\left(\frac{H_r + D_a 1 \cdot 0p^{r-a} + \ldots + D_n 1 \cdot 0p^{r-n}}{1 \cdot 0p^r - 1}\right) p}{B_p + V + \frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1}}$$

Adding to the numerator $\frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1} - \frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1} + V - V$

We get

$$p' = \frac{\left(\frac{H_r + D_a 1 \cdot 0p^{r-a} + \ldots D_n 1 \cdot 0p^{r-n} - c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1} - V + V + \frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1}\right) p}{B_p + V + \frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1}}$$

$$= \frac{\left(B_p + V + \frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1}\right) p}{\left(B_p + V + \frac{c\, 1 \cdot 0p^r}{1 \cdot 0p^r - 1}\right)}$$

$$= p.$$

In the same way, by putting $B = B_p$, it may be shown that for a series $p' = p$. The current return for a group or series at the end of the revolution is, therefore, under the conditions assumed, equal to the mean yearly return per cent. on capital-outlay (see also page 63).

AVERAGE CURRENT RETURN ON THE COST-VALUE OF AN ESTATE FOR MORE THAN ONE YEAR.

If we wish to know the return a group will yield on its present cost-value a given number of years hence, we may proceed as follows:—

Let H_m be the market-value of a group m years old; H_{m+q} that of the same group $m + q$ years old; D_b, the

value in the year b of all thinnings receivable subsequently to the year m, b being less than $m + q$, and more than m.

The productive capital for this group m years old, will be (see page 62).

$$[(B+V+c)-(D_a 1{\cdot}0\,p^{-a}+\ldots+D_n 1{\cdot}0\,p^{-n})]\,1{\cdot}0\,p^m$$
$$=(B+V)(1{\cdot}0p^m-1)+c\,1{\cdot}0p^m-(D_a 1{\cdot}0p^{m-a}+\ldots+D_n 1{\cdot}0p^{m-n})+B+V$$
$$=H_c+B+V, \text{ when } H_c = \text{cost-value of the group.} \quad \text{(See page 46.)}$$

In the year $m + q$, the increment on H_m will amount to $H_{m+q} + D_b\,1{\cdot}0\,p^{q-b} - H_m$, when H_{m+q} represents the value of the main cutting in the year $m + q$.

It remains now to find what rate of interest per cent. p', on $H_c + B + V$, will, in q years, amount to $H_{m+q} + D_b\,1{\cdot}0\,p^{q-b} - H_m$. This will evidently be found by putting

$$(H_c+B+V)\,(1{\cdot}0\,p'^q-1) = H_{m+q}+D_b 1{\cdot}0\,p^{q-b}-H_m$$

from which we get

$$1{\cdot}0\,p'^q-1 = \frac{H_{m+q}+D_b 1{\cdot}0\,p^{q-b}-H_m}{H_c+B+V}$$

hence

$$1{\cdot}0p' = \sqrt[q]{\left(\frac{H_{m+q}+D_b 1{\cdot}0\,p^{q-b}-H_m}{H_c+B+V}+1\right)}$$
$$=\sqrt[q]{\frac{H_{m+q}+D_b 1{\cdot}0\,p^{q-b}-H_m+H_c+B+V}{H_c+B+V}}$$

and

$$p'=100\left(\sqrt[q]{\frac{H_{m+q}+D_b 1{\cdot}0p^{q-b}-H_m+H_c+B+V}{H_c+B+V}}-1\right)$$

Pressler calls p' the *Index*, because it serves, under certain circumstances, to indicate if a group is exploitable from a financial point of view, or not. If, for instance, the prospective value is taken as the value of the land, p' is (as shown at page 63) greater than

the largest mean yearly return per cent. before the end of the financial revolution, but less afterwards. If, therefore, p' is found to be greater than the highest mean yearly return on the capital-outlay, that is, under the conditions assumed, than p (see page 68), the group is not ready for cutting; but if it is equal to, or less than, p, it is mature or over-mature, and should be cut.

It does not, however, follow that because the index is higher than the average return on outlay before the latter culminates, it would be advisable to shorten the revolution. That which affords the highest mean yearly return on outlay, is obviously the most advantageous revolution in the long run.

Average Current Return on the Market-Value of an Estate for more than One Year.

If in the formula just considered, the market-value, H_m, of the main cutting in the mth year, is substituted for H_c, the formula becomes

$$p' = 100\left(\sqrt[q]{\frac{H_{m+q} + D_b\,1{\cdot}0\,p^{q-b} + B + V}{H_m + B + V}} - 1\right)$$

This formula, based on the market-value of an estate, can lead to the same results as that based on the cost-value, only when $H_m = H_c$, that is to say, at the end of the financial revolution. It may, however, be employed to determine financial maturity in place of the true index, because it always gives a percentage greater than p before, but less after, the end of the revolution. It has the advantage of simplicity, but its chief recommendation is that the cost-value of the

group does not appear in the formula. The market-value is generally ascertainable, but the cost-value of a group can be known only in those cases in which receipts and expenditure have been recorded since its formation.

In estimating the value of the land, the maximum prospective value should be taken, whenever the data necessary for determining it are available. To the proprietor who does not wish to sell his land, it is practically the market-value, since it represents the maximum amount which he could afford to give for the land if it were not already his.

Example.—A group is 80 years old, with immediate and prospective yields as shown below. The group is to pay 3 per cent. on its capital-outlay. May it be left standing 10 years longer?

Here

$$H_{80} = 1809{\cdot}3 + 60{\cdot}3 = 1869{\cdot}6\,; \quad p = 3$$
$$H_{90} = 2494 + 73{\cdot}6 = 2567{\cdot}6\,; \quad q = 10$$
$$V = \frac{2}{0{\cdot}03} = 66{\cdot}67$$
$$D_{80} = 60{\cdot}3\,; \; B_p = 166{\cdot}67$$

therefore

$$p' = 100\left(\sqrt[10]{\frac{2567{\cdot}6 + 60{\cdot}3 \times 1{\cdot}03^{10} + 166{\cdot}67 + 66{\cdot}67}{1869{\cdot}6 + 166{\cdot}67 + 66{\cdot}67}} - 1\right)$$
$$= 100\left(\sqrt[10]{\frac{2881{\cdot}98}{2102{\cdot}94}} - 1\right)$$
$$= 100\,(1{\cdot}032 - 1) = 3{\cdot}2$$

The group might therefore be left standing 10 years longer.

CHAPTER XI.

THE ASSESSMENT OF FORESTS FOR PURPOSES OF TAXATION.

The Rating Act of 1874 classifies forest property as follows:—

1. Land used only for the growth of a plantation or wood.

2. Land used for the growth of saleable underwood.

3. Land used for a plantation or wood, and also for the growth of saleable underwood.

"Land used only as a plantation, or wood," appears to mean land used only for the growth of *timber*. Such land is, according to the Act, to be treated, for purposes of assessment, as if the land were let and occupied in its natural and unimproved state; and irrespectively of the value of the wood growing on it.

If the land is used for the growth of saleable underwood, its value is to be estimated as if the land were let for that purpose, which virtually amounts to saying that it is to be valued according to the value of the underwood which it produces, or is capable of producing.

In the third case, either it is to be valued according to its natural or unimproved state, or as if the land

were used only for the growth of saleable underwood, as the Assessment-Committee may determine.

No doubt, the reason why the Act of 1874 does not provide that land used for a "plantation or wood," shall be rated according to the value of its produce, is to be found in the real or supposed difficulty of assessing correctly the annual return from woods subject to very long revolutions, or from purely ornamental plantations in which the trees are not cut on any fixed plan. In well-regulated woods and forests, there ought, however, to be no great difficulty in estimating the return with sufficient accuracy. The only way of determining the rent of such land under the Act, is to value it at the yearly sum obtainable for grazing-land of the same apparent quality in the immediate neighbourhood, which is the rule laid down by law for the assessment of all descriptions of forest-land in Scotland. The probability is, that woods assessed in this way, especially those subject to long revolutions, are too highly rated, as timber-forest, although it may be more profitable than moorland-grazings, seldom pays as well as grass.*

In Germany, the value of forests is generally calculated, for purposes of taxation, in the following way:—Let r be the length of the revolution, H_r the value of the main cutting in the rth year; D_a, D_b, ... D_n, the value of thinnings in the ath, b^{th} . . . . n^{th} years;

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* Wagner estimates that the average return on the value of the State-forests of Bavaria, that is to say, on about 300 millions thalers (£45,000,000), does not exceed $1\frac{1}{2}$ per cent. This, it must be remembered, includes the yield from the more profitable coppice, which would raise the general average. *Anleitung zur Regelung des Forstbetriebs nach Massgabe der nachhaltig erreichbaren Rentabilität*, p. 3.

c the cost of cultivation ; v the yearly expenditure for supervision, &c. The nett yearly income from the land is then estimated as—

$$\frac{H_r + D_a + D_b + \ldots\ldots + D_n - c - vr}{r}$$

A group is treated as if it were part and parcel of a model forest. In this way not only the land is taxed, but also the standing stock for a complete series, far exceeding the value of the land (see also page 9).

Example.—For a plot of land stocked with forest subject to a revolution of 90 years, and yielding the returns shown in the Table at page 6, the nett yearly returns calculated in the above way is

$$\frac{2494+13{\cdot}5+28{\cdot}1+48{\cdot}8+53{\cdot}4+58{\cdot}2+60{\cdot}3+73{\cdot}6-10-90\times 2}{90}$$
$$=\frac{2639{\cdot}9}{90}=29{\cdot}3$$

Evidently, the most equitable mode of estimating the value of all kinds of forest-land, whether stocked with over- or underwood, or both, would be to find the value at the beginning of the revolution of the receipts during the revolution, and to deduct from this sum the capitalized value of all expenditure by the formula described at page 17.

Example.—For a plot of land capable of yielding returns as in the last example, the annual equivalent income is

$$\left(\frac{2494+73\cdot6+13\cdot5\times1\cdot03^{60}+28\cdot1\times1\cdot03^{50}+48\cdot8\times1\cdot03^{40}+53\cdot4\times1\cdot03^{30}+58\cdot2\times1\cdot03^{20}+60\cdot3\times1\cdot03^{10}-10\times1\cdot03^{90}}{1\cdot03^{90}-1} - \frac{2}{0\cdot03}\right)0\cdot03 = 5.$$

This represents the nett yearly rental from the soil. Calculating interest at 3 per cent. per annum, we find therefore that, by the German method, the estimate of income from a plantation, subject to a revolution of 90 years and yielding the returns shown in the table, is nearly six times what it really is, and that, consequently, the rate payable would also be nearly six times what it should be.

PART II.—PRACTICAL APPLICATIONS.

INTRODUCTION.

IN examining the general principles on which the systematic management of a series is based, purely ideal conditions have hitherto been assumed, such as are—it is unnecessary to say—never met with. The impossibility of pre-determining the exact rate of growth of a group is alone sufficient to impair the accuracy of the most carefully-prepared plan ; and it is evident, at the very outset, that the organizer of a series can never expect to bring about a state of things exactly corresponding to the ideal. Nevertheless, he must work with some definite aim in view, and the ideal forest is to him what a perfectly frictionless machine is to the machinist, an object that may be always more nearly attained than before, if never completely. For this reason, amongst others, the plan of management of a forest can never be regarded as final; on the contrary, frequent revisions are necessary, in order that it may be known how the plan has worked, and what amendments it is necessary to introduce.

The practical work of organization consists in the following operations :—

I.—The Survey of the Forest Area.

II.—Differentiation.

Including the formation of ranges, blocks, compartments, sub-compartments, rides, and roads.

III.—Assessment.

Including an estimate of the stations of groups; an estimate of the age, height, and rate of growth of standing stock; yield of thinnings; the collection of statistics; and formulation of results.

IV.—Determination of Yield.

V.—Plan of Operations.

VI.—Booking Results.

VII.—Revision of Plan.

VIII.—Conversions.

SECTION I.—SURVEY OF THE FOREST AREA.

CHAPTER XII.

CHOICE OF METHOD AND SCALE.

THE choice of a method depends on the degree of accuracy required, which, again, depends on the importance and value of the forest. For land producing only firewood-scrub of little value, and, therefore, only a very small return, expensive surveys are evidently out of place. In India, for example, large areas of forest land are often met with, which are not capable of returning more than a few annas per acre per annum, and in their case accuracy should evidently be sacrificed to economy. The organizer will have no difficulty in determining, from personal experience, or from information obtainable on the spot, the method best suited to the requirements of each particular case. For large tracts, theodolite-surveys of the exterior boundaries, at least, are desirable, if the outlay can possibly be afforded; but surveys with plane-table, or prismatic compass, will generally suffice for minor details, such as the inner boundaries of groups, and topographical features. Mountainous country is most easily surveyed by triangulation; but in tolerably flat country, Gale's method is generally preferable for areas not exceeding 10,000 acres. Its advantages are most marked in level country and in tall forest, in

which distant objects can seldom be seen without much trouble and cutting of trees. Simple chain-surveys are seldom, if ever, suitable for forest work, and occupy more time in the long run on account of the difficulty, practically amounting to impossibility in most cases, of working in forests without instruments for measuring angles.

The principal points to be noted when surveying a forest for the purpose of organization, are :—External boundaries and their marks; the boundaries of areas to which rights or privileges are confined; all topographical features—such as streams, canals, ravines, valleys, hills, roads—likely to affect the laying-out of blocks and compartments, or the working of the forest.*

The original map should be on a comparatively large scale, certainly not less than eight inches to one mile, or $\frac{1}{7920}$.† A scale of $\frac{1}{5000}$ is much to be preferred. (See also the section on maps.)

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* As treatises on surveying are procurable anywhere, it is unnecessary to enter into details. An account of Gale's method is given in Captain Firebrace's book on surveying, published at Roorkee, N.W. Provinces, India. Kraft's "Anfangsgründe der Theodolitmessung und der ebenen Trigonometrie," published at Hanover, and written specially for the use of foresters, gives a concise and complete account of surveying.

† In India the 4-inch scale $\frac{1}{15,840}$ is used. It is a great deal too small to admit of plans fulfilling the principal objects for which they are required. All boundary-marks cannot always be shown on maps done to so small a scale, nor sufficiently accurate measurements made for purposes of organization. Many boundary-lines are only a few yards long, and would disappear altogether in a plan on which a length of 440 yards was represented by an inch. Maps of this kind look well enough, give a good *coup-d'œil*, and do very well for general purposes, such as inspections; but for detailed work they are almost useless. If a forest is worth surveying on a 4-inch scale, it is certainly worth surveying on an 8-inch scale.

SECTION II.—DIFFERENTIATION.

CHAPTER XIII.

FORMATION OF BLOCKS, COMPARTMENTS, RANGES, AND SUB-COMPARTMENTS.

When a map showing the boundaries and principal features of the land has been made, the forest should be divided into a number of blocks and compartments by means of a system of rides, or by natural divisions, or both. The object of this operation is to facilitate the survey of interior details and the estimate of standing stock: to ensure the carrying out of a regular system of cuttings and regeneration, which would be impossible in large forests not so parcelled out: to avoid the evil effects of exposing trees which have grown up in thick cover to wind and sun: to afford protection against fire: to admit of freedom in locating coupes: and to facilitate exportation, regeneration, and transport.

Rides are cleared lines in the interior of forests, and are of two kinds—*main* and *minor*. The former are made broad enough to admit of the trees on their edges throwing out vigorous roots and lower branches, and thus forming a protective fringe against wind. Minor rides may be made much narrower; their primary object is the division of the forest between

two main rides into compartments of convenient size. Sometimes, however, they are also used as fire traces, and have to be made as broad as the main rides.

The width of main rides depends on the station, kinds of tree, and treatment. In high-lying, exposed localities, subject to violent storms, their width has to be made greater than is necessary in sheltered parts of the county. Again, seedling-forests subject to long revolutions require broader rides than coppice, and trees with tracing roots greater protection than trees with pivoting roots. Fifteen to sixty feet may be taken as limits, and it may be assumed in a general way that a breadth of fifteen feet will suffice for coppice, and of thirty feet for seedling forest. When intended to serve as a protection from fire, rides should not be made less than thirty feet broad, and will often have to be made much broader.*

Minor rides need not exceed eight feet in breadth, provided they are not required for cart traffic, nor fire-traces. They should be laid out, if possible, at right angles to the main rides, which they serve to connect.

In flat, or undulating country, the best plan is to have a regular net-work, the main rides running parallel to each other, and in the direction usually taken by heavy storms, and the minor rides joining them at right angles. The distance apart of the main rides should not be too great to admit of a cutting being made along the whole length of the minor ride connecting two main rides. The forest will then be divided into a number of parallelograms or other figures, called compartments, whose size will

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* **In India they are sometimes 200 yards wide, or more!**

depend on the station, on topographical features, such as roads and streams, which may be conveniently used in place of rides, and on the kind and age of the trees inclosed. It is well to separate lands differing considerably in productiveness, and groups differing greatly in age, at the same time not forgetting that very large compartments are inconvenient, and that very small ones necessitate a great deal of land, taken from the productive area, being converted into unproductive rides. Twenty-five to seventy five acres or, in exceptional cases, one hundred acres may be taken, as limits. The sides of a compartment bounded by main rides should be about twice as long as those adjoining minor rides, so as to obtain the most convenient shape of compartment for cutting and protective purposes.*

The portion of forest lying between any two main rides (or their substitutes) is called a *block*.

Whenever practicable, it will be found convenient to lay out the net-work of rides before, or when actually surveying the interior features of the country. It will sometimes be possible to lay out the rides beforehand when rough maps of the forest already exist.

In mountainous country it is desirable that the main rides should follow the configuration of the ground. Roads, when not too sinuous, make the best boundaries of blocks and compartments, and the system of export roads should, therefore, be determined upon before the blocks are marked out. When main rides are laid out they should follow the lie

* The cuttings should for obvious reasons march parallel to the main rides along the whole length of the minor rides, and progress from the fair weather quarter towards the stormy quarter.

of the ground as much as possible—a course which will give them a horizontal direction. Natural boundaries, such as streams, ravines, valleys, ridges, afford convenient natural divides, and should be utilised in laying out lines of separation for blocks and compartments.

The accompanying sketch represents a hill-forest with main rides following the configuration of the ground, which is shown by means of contour-lines. The stormy quarter is on the left, and the cuttings of groups march in the main from east to west, in the direction indicated by the arrows.

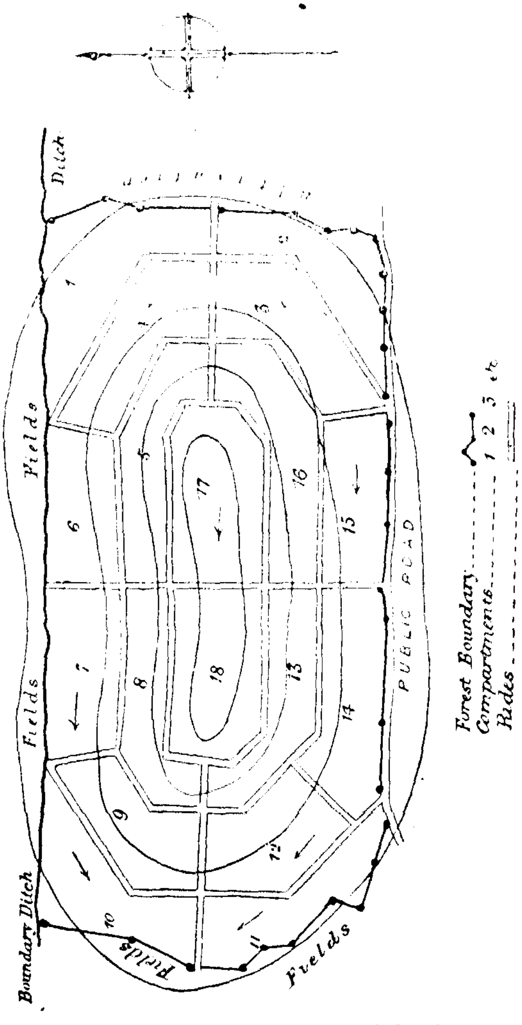
Minor rides are often practically main rides. Those in the sketch, for example, which separate 10 from 11 and 9 from 12 ought to be as wide as the main rides if the flanks of the compartments are to be properly protected.

Sometimes it is dangerous to open out new rides, running through high forest, to their full width, as the trees might suffer from sudden exposure to wind and sun. In such cases, the lines may be opened out to a breadth of a few feet, and so left until the forest is regenerated, and they can be enlarged without danger.

It will not always be found convenient to make a very accurate survey of the configuration of the ground, as that is generally an expensive and laborious affair; but it will always be possible to fix salient points, such as ridges or cones, inexpensively and expeditiously, with prismatic compass or plane-table, and to sketch in the rest by eye.

Very large areas have to be split up into smaller units called *ranges*, each one being in charge of a ranger, or manager, and distinctly marked off from

the others by natural or artificial boundaries. Their size depends upon the extent of forest which can be efficiently managed by one official. No general rules



can, however, be laid down. Special circumstances, such as the kind and quantity of work to be done,

and the situation and value of the forest, must decide the matter. A forest, for instance, producing a large crop of minor produce, as well as timber and firewood, would generally require smaller ranges than one yielding only firewood. Generally speaking, forests worked intensively, that is, those in which a comparatively large capital is locked up, require smaller ranges than those which are worked extensively, that is, which require a comparatively small outlay for their maintenance. Take, for instance, the case of a range yielding timber, firewood and valuable minor produce, and that of one simply producing firewood-coppice. Area for area, there would be a much larger capital involved in working the timber-forest, in which there would be a valuable standing stock and crop of minor produce, an establishment for guarding the latter, and for collecting, drying, and storing it, in addition to a large protective establishment for the forest generally. In the case of the range yielding only firewood, the standing stock would be of little value, comparatively speaking; the expenditure for guards would be small, and there would be no outlay at all on account of minor produce. Evidently, a ranger could manage a much larger extent of the coppice than of the other forest with its numerous *personnel* and accounts.

To enable foresters and workmen to find the compartments easily, roughly cut, small, numbered stones standing out 15 inches above ground, or, where stone is not available, wooden posts, should be erected at points where rides meet, and also at intermediate points in rides which are very long. The distance between these stones should not, as a rule, exceed two hundred yards. Where the expense of putting up

stones or posts is too great, or where there is fear of posts being burnt by running fires, it will often be found possible to throw up mounds of earth or stones, or to have the more durable kinds of mark at the corners and the less durable at intermediate points. They should be erected on the sides of rides, not in the centre, where they are more liable to be damaged and may interfere with traffic, and all should be on the same side of the rides, either on the right or left, so that they may be easily found. The numbers should be cut on the stone, and may be painted over to make them more easily distinguished.

All ride-stones and their numbers, as well as those of compartments, should be shown on the working-map, but may be omitted in general maps, which are too small for such details. (See also "maps," p. 236.)

When the organiser finds that the forest has already been split up into blocks, he should accept as far as possible existing subdivisions, only making such additions and alterations as appear to him absolutely necessary.

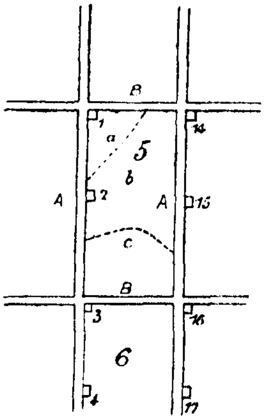


Figure showing ride-stones. —*A*, *A*, are main rides; *B*, *B*, are minor rides; 5 is the number of a compartment; *a*,*b*,*c*, sub-compartments; 1,2,3, &c. ride-stones.

It often happens that compartments contain groups of different species, or of very different ages and growth, or subject to different treatment. Groups differing in one or more of these respects have to be separated from one another by some inexpensive

means, such as wooden posts, small mounds of earth or stones, or by narrow cleared lines. Such boundaries are shown on the detail-map by means of dotted lines, and the area occupied by each group is called a *sub-compartment*. Each sub-compartment is known by a letter of the alphabet with the number of the compartment prefixed: thus, 5 *a* is sub-compartment *a* of compartment 5 (see figure, p. 87). Groups occupying an area of less than an acre need not be separated.

SECTION III.—ASSESSMENT.

CHAPTER XIV.

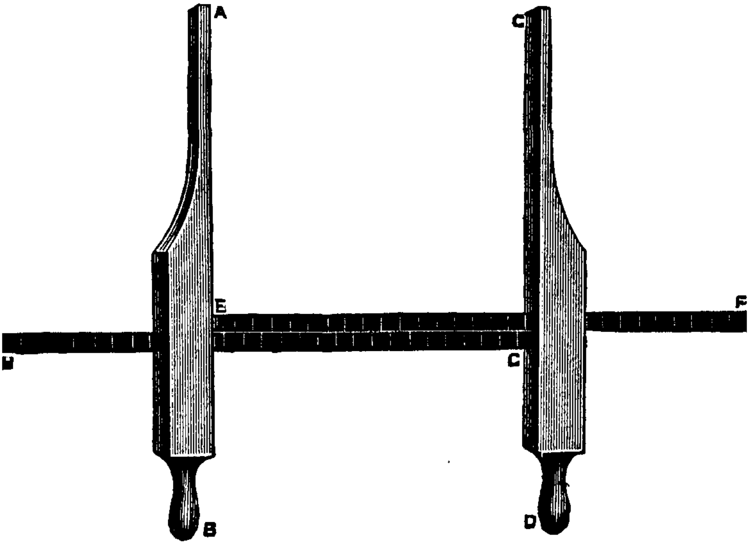
INSTRUMENTS REQUIRED.

BESIDES the ordinary surveying-tools, instruments are required for measuring the diameters or circumferences of trees and their heights, and for estimating the cubic contents of wood of irregular form, which cannot be directly measured.

DIAMETER AND CIRCUMFERENCE MEASURES.

One of the best forms of diameter-measure is the one shown in the accompanying diagram. The arms *AB*, *CD*, are made of well-seasoned teak or oak. The limb *EF* is fixed at right angles to *AB* at *E*, and slides through an aperture in *CD*. The limb *GH* is fixed at right angles to *CD*, and fixed to *CD* at *G*, sliding through an aperture in *AB*. *GH* is made to run along a V-shaped rail on *EF* to prevent the limbs from separating when one is drawn out beyond the aperture in *CD* or *AB*. The limb *EF* is divided from the point *E* into inches and fractions of an inch, the divisions being numbered from *E* to *F*, and continued along the lower limb from *G* to *H*; thus, if from *E* to

F is 24 inches, the first inch on *GH* would be marked at the end near *G*, and be numbered 25. In using the instrument, it is grasped by the handles at *B* and *D*, and its arms are placed so that the trunk to be measured shall be between them. *B* and *D* are are then pressed towards each other until both arms are resting against the tree: the diameter is then



The Diameter-Measure.

read off on the limb *EF*, or *GH*, as the case may be. This is a very handy and portable instrument. Its dimensions depend on the size of the trees to be measured. With arms 2 feet, and limbs 3 feet long, trees up to 5 feet in diameter may be conveniently measured.

For measuring circumferences an ordinary tape, or one of steel or leather, is used.

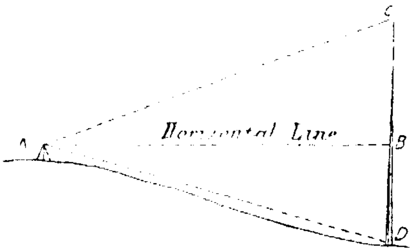
Trees can be measured much more expeditiously with the diameter-measure than with the tape; the latter may, perhaps, be slightly more accurate for *single* trees, but even that is doubtful, and, anyhow, whatever slight advantage is gained in this respect, is more than counterbalanced by the comparative slowness of the process. When many trees have to be measured, the advantage of greater accuracy probably lies in favour of employing the diameter-measure. When the bole is very elliptical, it may be measured in the directions of the major and minor axes, and the mean of the two readings taken. Some foresters recommend that masses of forest should be measured with the diameter-measure, but single trees, such as sample-trees, with the tape; others, on the other hand, think the tape should be discarded altogether.

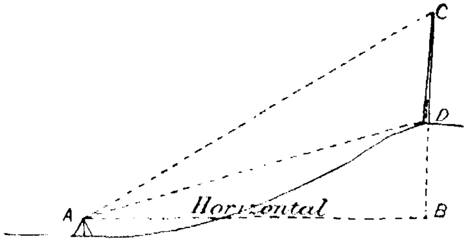
In measuring trees, allowance must be made for the thickness of the bark. This must be estimated for each diameter-class, and deducted after all measurements have been made in the field.

HEIGHT-MEASURES.

Many methods of estimating the quantity of standing stock involve the use of instruments for measuring the height of standing trees. A theodolite, or a level with vertical arc, is an excellent instrument for this purpose, but is troublesome to carry about, and its use takes up too much time to admit of its being generally adopted. The process of finding the height of trees with one is simple. Let *CD*, Fig. 1, be a tree whose height is to be measured.

Set up the theodolite, or level, anywhere, at A, if possible at a distance from the tree equal to about the height of the tree. Measure the angles BAC, BAD, and the horizontal distance (a) from A to the foot of the tree, D, along the ground *making allowance for its not being horizontal, if necessary.* (a) will be equal





to AB, and the height, H, of the tree will be found by the formula

$$H = (\tan BAC + \tan BAD)\ AB.$$

or since the measured length, $a = AB$,

$$H = (\tan BAC + \tan BAD)\ a.$$

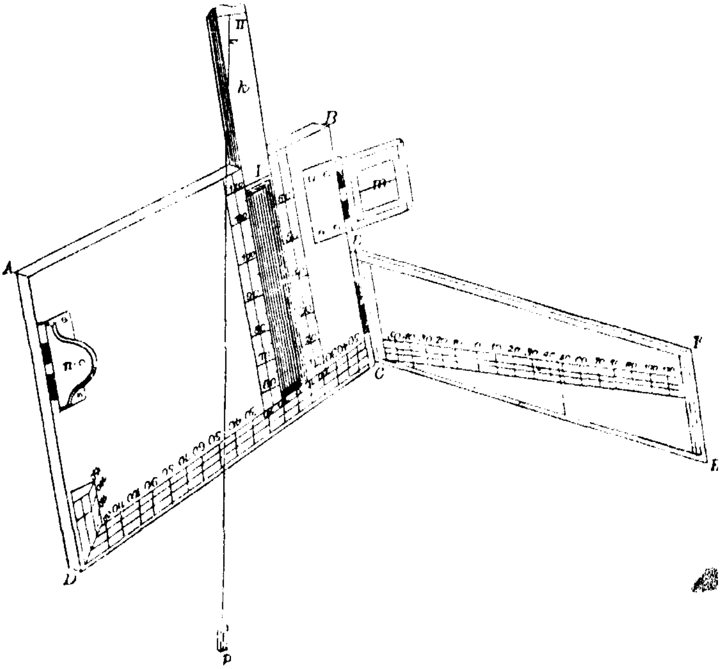
If the theodolite is below the foot of the tree,

$$H = (\tan BAC - \tan BAD)\ a. \quad \text{(Fig. II.)}$$

If the theodolite and the foot of the tree are in the same horizontal plane, the angle BAD disappears, and the formula becomes

$$H = \tan BAC \times a.$$

The reflecting hypsometer, invented by a German forester, is a more generally useful and thoroughly practical instrument. It consists of a rectangular board, *ABCD*, some 9 inches by 5 in size, whose lower edge, *CD*, is divided into 150 equal parts to the left of the centre of the plunger, *k*, and 50 to the



Faustmann's Reflecting Hypsometer.

right of that point, as shown in the figure. The plunger is movable up and down a groove in the board at right angles to *CD*, and kept in any required position by a spring placed in the groove behind it. The eye-piece, *n*, and the objective, *m* (consisting of a horse-hair wire), are fixed to the board, so that a

straight line connecting them would be parallel to *AB* and *CD*. *CEFH* is a mirror, by means of which readings can be taken at the same time as observations. The pieces *m* and *n*, consisting of brass, and the mirror, which has a backing of tin or brass, turn on hinges, and can be laid back flat on the board, so as to pack easily into a small case. On either side of the groove the distances from *CD*, on the same scale as the horizontal scale, are shown. The plumb-line, *p*, is fixed in the centre, and near one end, of the plunger. By raising or depressing the latter, which is fifty divisions of the scale in length, the distance of the point of suspension of the line from *DC* can be increased from 60 to 120, whilst by inverting the plunger, so that the end marked I is above, and that marked II below, the distance can be reduced to 10.

To use the instrument, measure the *horizontal* distance, in feet or yards, of the observer from the tree. Set the plunger at the same relative distance on the vertical scale; then, looking through the eye-piece, align the top of the tree with the hair at *m*, allowing the plumb-line full play. As soon as the latter is at rest, the number which it intersects on the horizontal scale can be read off in the mirror, and indicates the height of the tree, in feet or yards, as the case may be, if the observer's eye is on the same level as the foot of the tree; otherwise, a further observation will have to be taken to the foot of the tree, the result being added or deducted from that already obtained, according as the eye of the observer is above or below the foot of the tree.

The rationale of this method is as follows. In

figure I., let BD represent the tree, and A the hypsometer, on which ac represents the vertical, or, as it is called, distance-scale, and bc the horizontal, or so-called height-scale. Draw a horizontal line, AC, from the eye-piece, A, meeting the tree in a point, C. Then, since the tree grows vertically, ACB is a right angle; acb is also a right angle, and the two angles are therefore equal. BC is parallel to sb, therefore $Asb = ABC$; and As being parallel to bc,

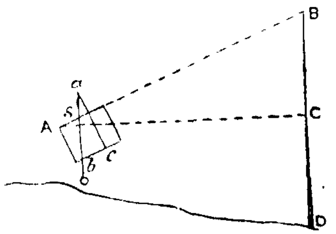


Fig. I.

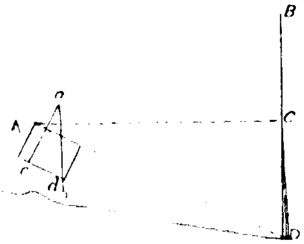


Fig. II.

sbc is also equal to Asb; therefore $sbc = ABC$, and the triangles ABC and abc are similar; and

$$BC : AC = bc : ac$$

but by construction AC is represented by ac, therefore BC is represented by bc.

In figure II., it is also evident that the triangle ACD is similar to the triangle acd, and that, therefore,

$$CD : AC = cd : ac.$$

and that AC being represented by ac by construction, CD is represented by cd; but the whole length of the tree is equal to $BC + CD$, therefore it is represented by $bc + cd$.

When the observer's eye is below the foot of the tree, as in Figs. III. and IV., it is evident that the

height of the tree will be found by deducting *CD* from *BC*. The values of *CD* and *BC* may be found in the manner just described, the observation for *BC*

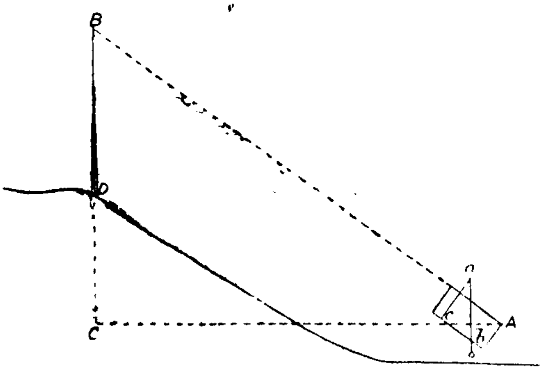


Fig. III.

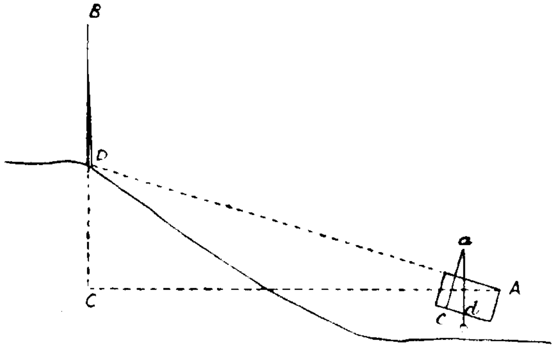


Fig. IV.

being taken to the top of the tree, whilst that for *DC* is taken to its foot.

Apparatus for Determining the Cubic Contents of Amorphous Wood.

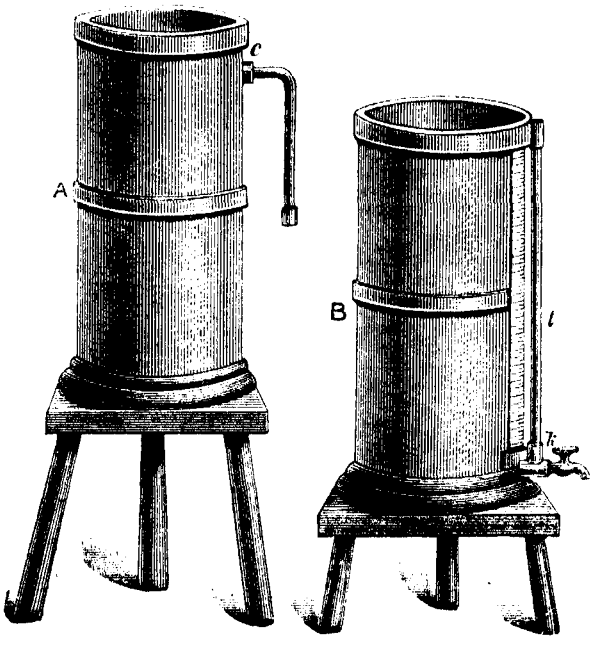
Firewood is generally, and small timber sometimes, sold in stacks or loads, the size of which may vary in different parts of a country, and the solid contents of

which is sure to be different for different parts of a tree. A stack of stem-wood contains, for instance, more solid matter than a stack of the same dimensions containing branches of the same tree. Wood of very irregular shape or very small size cannot be directly measured; hence the necessity of finding out the solid contents of a standard stack for different descriptions of wood (stem, large branches, and spray, for instance), and for different species separately. The process of measuring the contents of amorphous wood is tedious, and it would be impossible to measure every stack. The average of a number of experiments is, therefore, generally taken as a standard for a species, and for a whole district or country. Thus, in the Grand Duchy of Hessen, the average percentage of solid wood for all species is fixed as follows:—

Description.	Solid contents of Stack, cubic feet.	Dimensions of Stack.	Remarks.
Split stem-wood over 5 inches in diameter	70 per cent. of size of stack	4 by 6 by 12 feet	Wood sawn in 4 feet lengths and worked up at right angles to length of stack
Unsplit smooth or straight stem or branch wood, 2 to 5 inches in diameter	60 per cent.	Do.	Do.
Split stumps ...	50 per cent.	Do.	
Smaller spray ...	25½ per cent.	...	Branches 12 feet long and stacked in the direction of the length of the stack.

The result depends greatly on the way in which the wood is stacked, and on the dimensions of the pieces. Uniformity in these respects must therefore be strictly observed. Stacks of crooked, knotty wood, although of the same size as smooth, straight wood, should be estimated separately.

The solid contents of amorphous wood may be determined by means of the apparatus shown in the accompanying figure. A cylindrical vessel, *A*, about



Apparatus for determining the cubic contents of amorphous wood by the water-process.

four feet high and two feet in diameter, communicates with a similar vessel, *B*, by means of a tube at *C*. A glass tube, *t*, communicates at the bottom of the vessel

B with its interior, the water in which can be let off by means of the stop-cock, *k*. By means of a graduated metallic scale and the glass tube, the cubic contents of water in *B* can be read off. To graduate the scale, a vessel of exactly one cubic foot capacity is filled with water which is poured into *B*, which is placed in a vertical position. The water rises to the same height in the tube as it is in the vessel, and the height to which it rises indicates the distance on the scale corresponding to a cubic foot of water in the vessel. This distance is then divided into fifths or tenths, each one of which will correspond to the fifth or tenth part of a cubic foot of water. In this way the scale is graduated up to the top. By reducing the diameter of *B* to one foot greater accuracy will be attained, and the vessel need not be made any higher. The vessels *A* and *B* may be made of wood, but block-tin or zinc is preferable.

To use the apparatus, place *A* and *B* in a horizontal position, fill the vessel *A* with water up to the spout *c*, and place the mouth of the tube so that water passing through it will run into the vessel *B*. Then completely submerge the wood to be measured in the vessel *A*. This may be most effectually done by means of a finely perforated zinc or block-tin lid, exactly fitting the interior of *A*. The consequence will be that the submerged wood will displace a quantity of water equal to its bulk, which will overflow and run into the vessel *B*, when its cubic contents can be read off on the scale. The operation should be quickly performed, as wood soon absorbs moisture if left standing in the water.

CHAPTER XV.

DESCRIPTION OF THE STATION.*

THIS term is used to denote the climate, soil, and situation of a place. It is necessary to know the kind of station in which we are operating in order to determine what kinds of tree are best suited to it, and what sort of treatment should be adopted; also to enable us to predict the probable rate of growth of trees.

Climate.—This will be pretty much the same for all groups of a range, and need not be repeated for each one. Extremes of temperature, occurrence or absence of gales, droughts, moisture-laden winds (monsoons), hot or cold dry winds, the direction generally taken by violent storms, are the most important matters to note. Grain and other edible fruits growing in the immediate neighbourhood are often a good index to the climate, and may be noted. We know, for instance, that where wheat flourishes in Northern Europe the climate is comparatively mild, and suited to the growth of nearly all kinds of deciduous forest-trees, whilst where only oats can be got to grow well, the climate is raw and better suited to hardy conifers,

* The subject is examined generally, and with reference to each forest species, in books on sylviculture. It will suffice to give a general outline of it, and to refer the reader to works on sylviculture for particulars.

such as pine, larch, and firs. The growth of forest species is, of course, a still better guide for our purpose.

Situation.—The chief points to note are: height above the sea, whether table-land, mountain-range, lowland, or valley, angle and direction of slope (approximately), aspect.

Soil.—The kind of underlying rock should be noted. Depth and kind of soil (clay, loam, sand, &c., and their modifications); surface-deposits (such as gravel, stones, humus). Other physical characteristics such as colour, degree of moisture, power of absorption, permeability, may also be noted.

Surface-growths, not forming part of the forest (such as moss, bilberries, grass, broom, heather, ferns), are also very important as indicating the quality, moisture, and kind of soil.

Classification of Stations.

In forming a general opinion of the productive power of a station, with reference to a given species, the best guide is the growth of trees on the land itself, or on other land close to and similarly situated. An examination of the soil and climatic conditions will generally enable the forester to guess more or less correctly what species are best suited to the station; but will be but a poor guide to their rate of growth, or even the treatment or revolution to be adopted; whereas by observing the growth of a species on a particular soil, he will be much more likely to form a correct idea of the suitability of the station to that particular species, and of its rate of growth and the

best kind of treatment to adopt, than if he confined his attention to the examination of the soil and climate. The relative growth in height is, generally speaking, the chief point to note in judging the general growth of a tree.

It often happens that trees thrive well up to a certain age, when they begin to droop, as is sometimes the case when they are grown in shallow soils with a hard, impervious substratum, which checks the growth as soon as the roots touch it. On the other hand, it sometimes happens that trees are sickly until they attain a certain height, when they shoot up and grow vigorously to an advanced age; a circumstance that may be owing to some local climatic cause, such as their being retarded by frost until they reach a certain height. In such cases, a careful examination of the environment will sometimes enable the forester to find out and remove the obstacle, as in the case of moor-pan, or lead to important changes of treatment or species.

Trees which have been injured by game, cattle, or otherwise, are of course useless in an examination of this kind.

It is usual to have three, four, or at most five classes of station; and, as stations are different for different species, it is necessary to have separate classifications for each species. A good plan is to express the quality of the best station by unity, and the values of others as decimals of one. Thus the quality of a compartment stocked with oak and beech might be described as ·5 for oak, and ·75 for beech.

CHAPTER XVI.

Description of Groups.

The points to be noted are (1) the species, (2) their régimes and modes of treatment, (3) cover, (4) density, (5) cubic contents, (6) age, (7) increment.

1. The Species.

A group may consist of one or more species. In the former case, it is called *unmixed*; in the latter, *mixed*.

For mixed groups, the relative proportion of each species should be stated approximately, and the prevailing species mentioned first. The way in which they are mixed should also be stated whenever it can be ascertained. Thus, a group may be described as consisting of ·7 beech, naturally regenerated, and of ·3 oak in clumps.

2. Régimes and Methods of Treatment.

These are fully discussed in books on sylviculture. The following is an outline of the principal systems of which all others are modifications:—

I. Seedling-Forest, also called *high forest*, which has been raised directly from seed.

II. Coppice, which is the result of shoots from the stumps, stems, or roots of trees.

III. Under- and Overwood, also called *coppice with standards, stored coppice, composite forest,* which is a combination of seedling-forest and coppice.

Seedling-Forest is treated—

(1) By the Primitive Method, or *method of selection,* when each tree in a forest is cut out as soon as it becomes mature, without reference to other trees.

(2) By the Method of Regular Cuttings, when coupes are confined to comparatively small areas, on which all trees are cut at the same time, or nearly the same time, and the area, thus cleared, re-stocked artificially or naturally.

Regular cuttings may be divided into—

(*a*) Clean Cuttings, when all trees on a given area are cut away clean, and the forest artificially regenerated.

(*b*) Natural Regeneration Cuttings, when the trees are gradually removed, so as to effect the regeneration of the forest by seed in the natural way, and to afford protection for a time to the young growth.

Coppice-Treatment is similar to the treatment of seedling-forest subject to clean cuttings, with the sole difference that reproduction is differently effected, namely, by the shoots that spring from the stools or roots.

The form as well as the treatment should be noted. A group may have originated, for example, artificially from sowing or planting. In the latter case, the trees will have been planted at regular intervals, in lines, squares, clumps, etc.

3. Leaf-Cover, or Cover.

This term refers to the candpy of leaves of a tree, group, or forest. When the sun's rays are unable to pierce the foliage of a group, the cover is said to be *full*, or *complete*. Full cover is taken as the unit of comparison, and less degrees are expressed in decimals of it.

4. Density, or Absolute Density.

This term refers to the number of trees in a group. When an area is fully stocked, its absolute density is complete and expressed by unity; if incompletely stocked, the degree is expressed in decimals of one.

If the area is overstocked, that is, if the trees are so crowded as to be choking one another, a note should be made to that effect. In a fully-stocked group, the cover is generally complete; in an incompletely-stocked group, it is generally incomplete, and the state of the cover is often the best guide to determine the degree of density.

Blanks and Wastes.

When parts of a compartment, or sub-compartment are quite bare, they are called *blanks*. In noting blanks, it should be stated if they are temporarily bare, or permanently so on account of their being unculturable from physical or other causes. Large unstocked tracts are called *wastes*, and the reason of their being bare should always be noted.

5. Methods of Determining the Cubic Contents of Groups.

The principal methods employed will be found in the following synopsis :—

A. Involving no Direct Measurements.

I.—By Eye.

II.—By Experiential Tables.

(1). General Tables.

(2). Local Tables.

B. Involving Diameter-Measurements of all Trees.

III.—By Means of Size-Classes.

(1). Involving the Use of Sample-Trees.

(*a*). Of one sample-tree only.

(*b*). Of a sample-tree for each size-class.

(2). By Tables showing the Contents of each Tree.

IV.—By Pressler's Method.

V.—By Employing both Size and Height-Classes.

C. Involving Diameter-Measurements of only a Portion of the Trees.

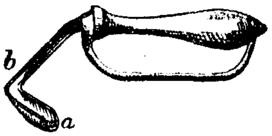
VI.—By Means of Sample-Areas.

A.—Methods Involving no Direct Measurements.

I.—By Eye.

In this case, the assessor walks through the group from end to end, estimates by eye the contents of each single tree, or judges the whole contents at once from personal experience of the cubic contents of trees growing under similar circumstances.

If the contents of each tree are judged singly, he will have to mark each one as he proceeds. This may be done by putting a daub of coloured liquid or paint on the tree, or by blazing the trunk with an axe, or, better still, by means of the instrument shown in the accompanying figure; *a* is a gouge-shaped steel cutter at the end of an arm *b* five inches long. This blazer is more handy than an axe, and its use is to be preferred to colouring matter, which is apt to be washed away by rain.



The Gouge-Blaze.

The results obtained by this method, even when carried out by men of long experience, are extremely uncertain, and cannot be relied upon to approach nearer than 60 per cent. of the actual quantity estimated. A minor objection to the method is, that there is no means of checking the work done by the assessor. For purposes of organization, it is, therefore, not to be recommended.

II.—By Experiential Tables.

These consist in tables showing the yields per acre of a species, from year to year or from period to

period, under given conditions of station and environment. Tables should show the yield per unit of surface; in England, therefore, per acre.

Without experiential tables, neither the laws of growth, nor the determination of the most advantageous revolution and treatment, nor the prospective value of forests, could be ascertained. They are also useful in other respects; to determine, for instance, the quality of the station, or the progressive yield of superior timber as compared with smaller descriptions and firewood.

Experiential tables may be constructed with a view to their being employed generally throughout a country, or simply for local use. Tables for general use must be constructed on the average results obtained by numerous experiments in various parts of the country for which they are intended. There can be little doubt that groups of the same height and age, which have grown up under similar conditions, will have the same form-coefficients, and, consequently, also the same cubic contents, no matter where they are grown within reasonable geographical limits, as, for example, within an area of the size of Great Britain, or of France, or even of Germany. It is seldom, however, that the previous treatment of a group is known, nor is it likely that any two groups ever grow up under exactly the same conditions of environment and station. It is, therefore, desirable that local tables should be constructed wherever great accuracy is essential, as in valuable forests managed on the financial system, or on those systems which require that the yield shall be determined for a whole revolution in advance. At the same time, it must be

admitted that for large proprietors, as, for instance, the State, it is a great advantage to have a uniform classification, and that to a certain extent accuracy may sometimes be sacrificed in their case in order to attain this end.

It is usual in constructing tables of yield of a species, to have three, four, or even five classes; as groups of the same age and species vary greatly in the quality and quantity of their yield according as the station is favourable to their growth, or otherwise. The yield of any given class may be fixed by determining the quantity of material of representative groups of the required quality.* The method of classification generally adopted is more or less arbitrary. The usual way is for the assessor to choose one or more well-stocked representative groups from among the most flourishing and best conditioned, to measure them after thinning, and to give the average result per acre as the yield of the last; or, if there are five, of the fifth class, and so on until he comes down to groups of the worst class. In this way there may not be great difficulty in selecting samples of the best and worst classes, but the determination of intermediate classes is assuredly extremely difficult, and more or less hap-hazard. The class to which a representative group belongs is by this means not made to depend on the quantity of wood it contains, but the quantity of wood is made to depend on the class to which, in the opinion of the assessor, it should belong, without reference to its cubic contents. Everything

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* A *representative group* here means a group which appears to the assessor to be a fair average representative of its class.

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* A *representative group* here means a group which appears to the assessor to be a fair average representative of its class.

is thus left to depend on the idiosyncrasies of the assessor. Perhaps a better plan, which will be described further on, is to reverse this order of things, and to allow the quantity of wood to determine the class.

The following are the principal methods employed in estimating the yield of a class for different ages of a species, and the position of groups in the classification :—

1. *The same representative group of a class is measured from year to year, or from period to period. In the latter case the average yearly increment is taken as the yearly increment for the period, and the yearly yields are made out accordingly.*

2. *Several groups of different ages* (15, 21, 30, 49, 60, 70, 79, 85, 91 *years old, for example*) *are selected for each class, and the yields for intermediate years interpolated in arithmetical progression.*

The former of these methods is too slow, as it would take nearly a whole revolution to obtain a table of yields by it. It is quite possible, too, that a group which belonged at one time to the fifth class might fall off in vigour, and become a first class group before the end of the revolution.

With regard to the latter method, its chief defect is that one cannot be certain that all the groups chosen are really of the same class; indeed, one may be pretty certain that some are not. Its chief recommendation is, that the yields of all ages of a class are fixed at once.

3. *Certain of the* oldest *groups only of each class are*

*selected, and the size of representative trees of younger groups deduced from them.**

In 1824, Huber propounded the theory that a tree which was found to be average-sized, as regards its diameter, at the end of the revolution, had in all probability been an average-sized tree from youth upwards. From this he concluded that all that was necessary was to search out an exploitable representative group of the required class; to find the diameter of its representative tree (by a method hereafter to be described); to fell a tree of diameter so found; and to determine the diameter of average trees of previous years by measuring its annual layers corresponding to the then ages of the tree. The representative trees thus estimated were then to be taken as standard representatives of all other groups of the same respective ages and classes. Supposing, for instance, it was found by felling a tree in a third class mature group, one hundred years old, that its representative tree in the fiftieth year had been 8¼ inches in diameter, 8¼ inches would be the standard of the third class for groups fifty years old, and if any group fifty years old was found to have a representative tree 8¼ inches in diameter, it would, according to Huber, belong to the third class, and its contents might be estimated to find the standard yield of a group of that age and class. If, on the other hand, its representative tree had a greater or less diameter it would belong to a different class.

* The *representative tree* of a group is one which is estimated to represent the average size of all trees of that group. Thus, if a group of 1,000 trees has total contents of 40,000 cubic feet, its representative tree would have contents of $\frac{40000}{1000} = 40$ cubic feet.

It will suffice to mention one objection to this method, namely, that a tree which was of average size in the earlier part of the revolution would no longer be so at the end. An average-sized tree of a group in its 40th year, for example, would be one of the dominated class at that time, and, in all probability, no longer represent an average-sized tree at the end of a longer revolution. If we take, for instance, Baur's estimate of the number of trees in a beech group of the fifth class, there would be 3,400 trees to the hectare, when the group was forty, but only 480 when it was 120 years old the number having been gradually reduced by the smaller stems having been by degrees suppressed or thinned out, of which our former average stem would surely be one. And this view has been fully verified by experiments in Brunswick, where 1,857 groups were repeatedly examined in the years 1862, 1867, 1872, and 1877, the result being that in each case the average-sized tree in one year did not keep pace with that of a later year.* Other objections to this method might be advanced. It does not, for instance, follow that because the diameter of representative trees of two groups are the same, their cubic contents are also the same. It would be necessary for this that their heights and co-efficients of form should also be equal.

The following plan, proposed and carried out by Hartig, is a modification of the above.† An exploitable group representing the class whose yield is to be determined is first cleared of all suppressed trees and

* *Allgemeine Forst-und Jagd-Zeitung*, 1878, p. 113.

† *Die Rentabilität der Fichtennutzholzwaldungen*, &c., 1868.

those interfering with the proper growth of the group generally. The sum of the areas of the bases, at 4½ feet from the ground, of all remaining trees is then made out by actual measurement and divided into 4 to 6 equal parts, each representing a sub-class. The first sub-class is then made to contain as many of the largest trees as are necessary in order that the sum of their basal areas shall be equal to the basal area of the sub-class. The next sub-class contains the next largest trees, with, of course, a sum of basal areas equal to that of the first sub-class, and so on to the last sub-class, with the largest number of trees. In this way the sub-classes are made to represent approximately equal quantities of material. The sum of the basal areas of a class is then divided by the number of the stems it contains, the quotient being the average basal area of a tree of such sub-class. A tree of the basal area thus found is felled for each sub-class and cut up into eight-feet lengths, for the purpose of determining the cubic and diametral increment for five years' periods by measurement and by counting the annual layers. At the same time, the rate of growth in height is estimated by the differences in the number of annual layers in the several sections. If, now, sub-classes containing the largest trees of a younger group are found to have about the same number of trees and the same rate of vertical, diametral, and cubic growth as the corresponding sub-classes of the representative group, for example, of the first class, were found to have, the group would, according to Hartig, belong to that class, and might serve as a standard of yield for it.

By Hartig's method, the number of largest trees in

a group fixes its class. It must have as many large trees as the representative group had, at the same age, in order to belong to the same class. His method is, therefore, more likely to give accurate results than Huber's, which is based solely on the size of the average tree; but a serious objection to it is that the yield of a class is determined by experimenting on one sample-group only. It is only by experimenting on a number that accurate average results can be expected. Hartig virtually postulates that all groups, whose sample-trees have a basal area equal to that of an average-sized tree of a given class, have grown up under exactly similar conditions. If we consider that some groups may have originated from planting, others from sowing, whilst some may have been thinned regularly, and others spasmodically, or not at all, we at once perceive—without mentioning a hundred other possible disturbing influences—the impossibility of admitting this assumption. It is, in fact, pure chance if Hartig's representative trees ever really correspond to the average trees of the classes they represent.

Another objection to the method is that it is extremely complicated, laborious, and difficult of execution, more particularly when the growth of a species is slow, and its annual layers are ill-defined.

3. *A number of groups of different ages are measured, their respective contents calculated, and the yield of each class graphically determined for all ages by means of curves.*

This method was first adopted by Baur in the construction of tables for beech and fir.* He measures

* *Die Holzmesskunde*, 3rd edition, p. 242.

a number of representative groups of all ages and classes in various parts of the country, or tract, for whose forests tables are to be constructed. It is desirable that about the same proportion of each class should be taken, and in choosing groups this should be remembered, because, although the classes are not fixed beforehand, the assessor, after some practice, attains such proficiency that he can estimate the class of a group with tolerable accuracy before it is graphically determined. The groups selected should be fully stocked, and occupy an area of not less than three quarters of an acre; and for five classes not less than 150 experimental groups, or 30 per class, should be examined. If they require thinning, they should be first thinned to the usual extent, the remaining trees then measured, and the quantity of branches, stem-wood, average co-efficient of form, height, and the sums of the basal areas, ascertained for each group. For the purpose of calculating the yield Draudt's method is the best.* The thinnings are booked separately, and the experimental groups marked on the ground and the map, so that they can be repeatedly examined in subsequent years. The station and general appearance of each group is also described.

The above operations concluded, the assessor passes on to the graphic representation of the contents of each group, separating (1) the yield of log wood from (2) the yield of smaller wood and branches. For this purpose, a horizontal line (abscissa) is divided into as many equal parts as there are years in the average age of the oldest group; the divisions, thus representing one year each, are numbered successively from

* Described at page 131.

left to right, and ordinates drawn from them on one side of the abscissa. The cubic contents of the experimental groups are then marked off on the ordinates, on a suitable scale, and at the points on the abscissa corresponding to their respective ages. The number of cubic feet in a group corresponds to the length representing that group's ordinate, the distance being marked off by a dot or circle, which may be numbered so as to correspond to the number of the experimental group. This numbering is not absolutely necessary, but it enables the experimenter to see with what degree of success he has classified the groups.

To determine the limits of the classes, the highest points on the ordinates are all joined together in one line, and the lowest points in another line, both lines meeting the abscissa in the year 0. These two lines represent respectively the highest and lowest limits of the classes. The positions of the intermediate class-lines are fixed by dividing the portion of the last ordinate which joins the two class-lines into a number of equal parts answering to the number of classes to be constructed. If there are to be five classes altogether, four distances will have to be inserted. Curves are then drawn joining each of these points with the point 0 of the abscissa. In drawing out the first two lines a gentle curve should be maintained, which will sometimes pass slightly above and sometimes slightly below the points which it should intersect; an angular zigzag line is to be avoided. The spaces between the lines represent the ranges of the classes respectively; the groups whose ordinates terminate in the second space from the top belong to the third class, for instance, supposing that there are four classes.

The average cubic contents of a class will then evidently be found by drawing a curve through its centre from the last ordinate to the point 0. The average cubic contents of a group 50 years old of the fourth class will, therefore, be found by measuring the length of the ordinate number 50 to the top continuous curve; that length on the scale being the equivalent yield in cubic feet of the group.

The mean heights, &c., of the groups experimented

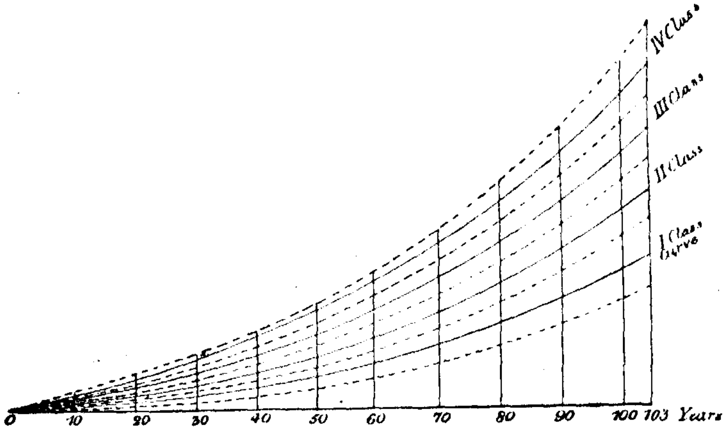

Figure illustrative of the graphic method of finding the cubic contents of groups—for four classes.

upon may also be regulated by a system of curves. The heights of representative trees of each group examined are laid off on ordinates in the manner just described, and the heights for different ages determined accordingly. Baur found, when constructing tables for spruce and beech, that the average height of the classes varied as their cubic contents; that the greater mass always corresponded to the greater height. If this rule is found to hold good generally,

it is a valuable discovery, because in that case we shall have a very simple means of determining the class of a group. It cannot, however, be considered an established fact until Baur's investigations have been verified by numerous experiments on a large scale.

This method has the great advantage over all others of comparative simplicity, rapidity, and easiness of execution, and of the yield being made to determine the class, instead of the class determining the yield, nothing in this respect being left to the idiosyncrasy of the assessor. A large number of representative groups are examined, and, setting aside the question of intrinsic merit, more reliable averages may, therefore, be expected, than from methods by which, on account of their laboriousness, comparatively few groups are examined.

The determination of the contents of groups of intermediate classes is evidently not absolutely necessary by Baur's method. So far as the determination of the intermediate curves of contents is concerned, it would evidently suffice to examine only the best and worst groups. In that case, however, the relation of the heights of groups to their cubic contents could not be ascertained, and this is a most important point to determine if, as appears probable, Baur's supposition is correct.

Experiential tables should contain details of the yield, divided at least into *log wood* and *other wood*, and also of the mean age and height. Other matters of useful information, such as the mean yearly and current growth may also be given, but too much should not be crowded into one statement. It is,

therefore, usual to have separate tables of the main yields (main cuttings), of thinnings, &c.

The yields should be given at intervals of five or ten years; the average increment during an interval being taken as the yearly growth during such period.

The tables are used in the following manner to estimate the contents of groups. Supposing that a group to be examined is of about the same age, height, and density, as a group in the tables which shows a yield per acre of 3,000 cubic feet. If this group covers an area of 10·5 acres, fully stocked, its contents will amount to 3,000 × 10·5 = 31,500 cubic feet. But if the area is not completely stocked—if, say, it is estimated by measurement, or eye, to be only half-stocked—the contents of the group would amount to only 31,500 × ·5 = 15,750 cubic feet.

To use the tables to determine the class to which a group belongs, we look up in the tables the class of the group most nearly corresponding to it as regards age and height.

It is desirable that the representative groups, by means of which the tables were constructed, and the group under examination, should be of about the same relative density, because groups of the same average height and age may vary very considerably if their relative densities are not about the same; the absolute densities, owing to blanks, &c., may, of course, differ without affecting the accuracy of the result.

Very great accuracy cannot be claimed for any method of estimating the contents of groups by experiential tables even under the most favourable

circumstances; but they often afford a cheap and sufficiently accurate means of determining the contents of regular, well-stocked groups.

One of the chief uses of experiential tables is to enable the assessor to predict the probable future increment of a group.

The following tables show the yield of an acre of land for Scots' pine, according to Burckhardt.* Thinnings, branches, and stumps are not included. The estimate is the average result of extensive experiments in different parts of the province of Hanover.

Age of Group.	Class V. Cubic ft.	Class IV. Cubic ft.	Class III. Cubic ft.	Class II. Cubic ft.	Class I. Cubic ft.
20	1,800	1,400	1,100	800	700
30	2,800	2,300	1,800	1,400	1,100
40	4,000	3,300	2,600	2,100	1,600
50	5,300	4,400	3,500	2,600	1,900
60	6,500	5,400	4,200	3,200	2,100
70	7,700	6,300	4,900	3,500	2,300
80	8,600	7,000	5,300	3,900	—
90	9,500	7,500	5,600	4,000	—
100	10,000	7,900	5,800	—	—
110	10,600	8,200	—	—	—
120	10,900	8,400	—	—	—

The following table of the yield of spruce of the best class was constructed by Baur† by the method of curves above described. He also gives four inferior classes.

* *Hülfstafeln für Forsttaxatoren*, p. 205.
† *Die Holzmesskunde*, p. 255.

TABLE OF YIELDS PER ACRE FOR SPRUCE: BEST CLASS.

Age of Group.	Mean height of Group.	Cubic Contents.	
		Wood in Log only.	Wood in Log and other Wood, including Branches.
	Feet.	Cubic feet.	Cubic feet.
5	1	—	215
10	3	72	572
15	8	501	1,140
20	14	1,001	1,959
25	24	1,616	2,889
30	34	2,604	3,947
35	42	3,232	4,948
40	50	4,276	5,892
45	56	5,234	6,793
50	62	6,078	7,523
55	67	6,807	8,165
60	72	7,465	8,809
65	77	8,108	9,395
70	82	8,680	9,967
75	87	9,252	10,482
80	92	9,824	10,982
85	95	10,386	11,483
90	98	10,897	11,983
95	101	11,397	12,470
100	105	11,898	12,899
105	108	12,341	13,328
110	111	12,427	13,757
115	113	13,085	14,157
120	115	13,442	14,515

B.—Methods Involving Diameter-Measurements of all Trees.

III.—By means of Size-Classes (1) Involving the Use of Sample-Trees.

If in a group of a model-forest, as defined in the first chapter, we were to cut down and measure one of the trees, we could obtain the cubic contents of the whole group by multiplying the contents of the measured tree by the number of trees composing the group. A tree used in this way to determine the contents of a group is called a *model, sample, representative*, or *average* tree, because it represents the average contents of one tree of the group.

Groups with trees all of uniform growth are, of course, never met with. In actual practice it is necessary to find out an average tree amongst a number of trees of different heights and forms. Average-trees may be determined by various methods, of which the following are the principal :—

(*a*). *By felling one Sample-Tree for the whole Group.*

In this case the trees of a group are divided into classes according to their diameters or circumferences at breast-height (4½ feet). They are then measured at the same height from the ground, and the diameter, or girth, of a tree of average size deduced from the result. Several trees of the diameter or girth thus obtained are felled and measured, and their average cubic contents determined. The cubic contents of the whole group is then found by multiplying the average

cubic contents of a sample-tree by the number of trees in the group.

This process may be carried out in the following manner,—

For reasons already stated, it is, as a general rule, far better to measure the diameters instead of the girths of trees. We will, therefore, assume for the future that diameters are always taken for the purpose of determining the basal areas of trees, and that all measurements are made at a height of $4\frac{1}{2}$ feet from the ground, unless the contrary is expressly stated.

The range of each diameter-class must first be fixed. The smaller the range the more accurate will be the resulting basal areas. Supposing that a quarter of an inch is fixed as the common difference, then eighths of an inch would be neglected and rounded off to quarters. The classes would be 6—$6\frac{1}{4}$ inches, $6\frac{1}{4}$—$6\frac{1}{2}$ inches, $6\frac{1}{2}$—$6\frac{3}{4}$ inches, &c.

The measurements may be carried out in the following manner:—Two or more workmen provided with diameter-measures are drawn up in a line at a corner of the group to be measured and at right angles to one of the sides. Each one is accompanied by *a man provided with a bark-blazer* (see fig. p. 107) or with a pot of colouring matter and a brush. Behind the line stands a clerk, paper and pencil in hand, ready to note down the measurements of the front rank. The whole squad then moves in line from one end of the group to the other, the measurers measuring and calling out the kind and diameters of the trees as they advance, and the markers, or blazers, marking with paint, or blazing, as the case may be, the trees measured, in order that they may not be measured twice by mistake. Sometimes the measurers

mark the trees, when the special markers are, of course, not required. Arrived at the other end of the group, the squad wheels round and takes up a fresh bit of ground, proceeding in this way to and fro until the whole group has been examined. In very open forests of large trees it will often suffice to mark only the trees on the edge of the line. To make sure that measurements are made at the proper height from the ground, a mark may be made on the chest of each measurer at the required height.

The clerk notes down the results in the following form:—

Diameter inches.	Scots' Pine.	Total.	Spruce.	Total	Larch.	Total.	Remarks.
6–6¼ 6¼–6½ 6½–6¾ 7 &c.	𝍸 𝍸 𝍸 /// &c.	18	𝍸 𝍸 𝍸 𝍸 // &c.	22	/// &c.	3	Three beeches were included under Scots' Pine.

As soon as four trees of a class have been noted, the fifth is marked down by a dash across, thus :—𝍸 This mode facilitates adding up results. Sometimes simply dots are used instead of strokes, and arranged

in twenties, thus

```
. . . . .    . . . . .    . . . . .
. . . . .    . . . . .    . . . . .
. . . . .    . . . . .    . . . . .
. . . . .    . . . . .    . . . . .
```

A far greater number can be got into the same space

in this way. When the trees have been all measured and booked, the number in each class is added up.

The diameter of an average tree must then be determined.

Let $d_1, d_2, d_3, \ldots \ldots d_n$ represent the diameters of each class respectively, $n_1, n_2, n_3, \ldots \ldots n_n$ the number of trees in each class, respectively, and $a_1, a_2, a_3 \ldots \ldots a_n$ the areas of circles of diameters $d_1, d_2, d_3 \ldots \ldots d_n$.* The average area ($a$) of all these circles will be found by the equation

$$a = \frac{n_1 a_1 + n_2 a_2 + \ldots \ldots + n_n a_n}{n_1 + n_2 + \ldots \ldots + n_n}$$

Here it is necessary to digress for a moment to explain the meaning of the term *co-efficient of form.* If trees were perfect cylinders, their contents would be determined by multiplying their basal areas by their heights. As is well known, the form of a tree is never that of a cylinder, and its contents will have to be found by multiplying the product of these two magnitudes by a constant which is called the *form-coefficient.* If h is the height of a tree, a its basal area, f its co-efficient of form, c its cubic contents, then

$$c = a \times h \times f \quad \ldots \ldots \quad (1)$$

$$\text{and } f = \frac{c}{a \times h} \quad \ldots \ldots \ldots \quad (2)$$

The co-efficient may be for the whole tree (including branches), in which case it is called *tree*-coefficient, or for the stem portion only, when it is called *bole*-coefficient.

---

* If the diameter (d) of a circle is given, its area is $\pi \left(\frac{d}{2}\right)^2 = \cdot 7854 \times d^2$.

The cubic contents of n trees would be, by the above formula—

$$a \times h \times f \times n.$$

Therefore—to return to the formula for finding the average basal area of a number of trees of different diameters—their cubic contents will be

$$a_1 h_1 f_1 n_1 + a_2 h_2 f_2 n_2 + \; . \; . \; . \; . \; + a_n h_n f_n n_n$$

or if $h_1 = h_2 = h_n = h$

$$h (a_1 f_1 n_1 + a_2 f_2 n_2 + \; . \; . \; . \; . \; + a_n f_n n_n).$$

But the cubic contents of the group is also equal to the contents of the average-tree multiplied by the number of trees in the group.

$$\therefore \; h . a . f . (n_1 + n_2 + \; . \; . \; . + n_n) = h (a_1 . f_1 . n_1 + a_2 f_2 n_2 + \; . \; . \; . + a_n . f_n . n_n).$$

When h is the height, a the basal area, and f the co-efficient, of the average-tree.

If, now, we assume that the co-efficient of form is the same throughout as the average one, f—which, considering that the trees are all of the same height, is not an improbable contingency—we get

$$a (n_1 + n_2 + \; . \; . \; . \; . + n_n) = (a_1 n_1 + a_2 n_2 + \; . \; . \; . + a_n n_n)$$

$$a = \frac{a_1 n_1 + a_2 n_2 + \; . \; . \; . \; . \; . + a_n n_n}{n_1 + n_2 + \; . \; . \; . + n_n}$$

The area of the circle corresponding to the average diameter being found, it is an easy matter to find the diameter corresponding to it. A number of trees of the same diameter are felled, the cubic contents of each determined, and the average taken as the contents of the sample-tree. The number of trees in the group multiplied by the cubic contents of the sample-tree gives the cubic contents of the group.

Example.—Supposing the trees of a group are measured and found to contain

100 trees of	10 in.	diam. each;	with, therefore,	basal area each of	·545	sq. ft.
200 „	10½	„	„	„	·601	„
250 „	11	„	„	„	·660	„
180 „	11½	„	„	„	·721	„
200 „	12	„	„	„	·785	„
140 „	12½	„	„	„	·852	„
130 „	13	„	„	„	·922	„

Inserting these values in the formula we get

$a = (100 \times \cdot 545 + 200 \times \cdot 601 + 250 \times \cdot 660 + 180 \times \cdot 721 + 200 \times \cdot 785 + 140 \times \cdot 852 + 130 \times \cdot 922) \div (100 + 200 + 250 + 180 + 200 + 140 + 130) = 865 \cdot 62 \div 1200 = \cdot 721$ sq. ft.

This corresponds to a diameter of 11·5 inches.*

A sufficient number of trees of the required diameter are then felled and measured. The boles are measured in lengths of not more than 10 feet. The diameter of the centre of each section is measured, and the contents of each length found by multiplying the corresponding area of a circle by the length of the piece. Amorphous pieces, such as crooked branches and spray, may be stacked, and their contents deduced from results previously obtained for the cubic contents of stacked wood of the same description; or the contents may be calculated in the manner described at p. 98 for the determination of the contents of amorphous wood. If more than one species occur in the group, each will have to be examined separately if largely represented.

Another method of determining the contents of sections is to treat each as a truncated paraboloid, whose

---

* Calculations of this kind may be greatly shortened by using the tables in the last chapter.

contents may be estimated by the formula $(M + N) \frac{h}{2}$, when *M* and *N* represent the areas of the ends of the frustum and *h* its height; the former method is, however, more simple, and just as accurate.

(*b*). *Method of determining the Contents of Groups by felling a Sample-tree for each Class.*

The method just considered is evidently applicable only to the case of groups in which the trees are all of about the same height and diameter. Should this not be the case, it is advisable to treat each class separately, or at all events to limit the number of classes for which one sample-tree is felled. It is usual to unite for this purpose 3 to 5 classes under one major class. The number thus united depends on the degree of irregularity of the group, and of accuracy required. Each major class is treated as if it were a group apart, the sum of the contents of the several major classes constituting the yield of the whole group.

Example.—Supposing it had been decided to convert the classes of the group, referred to in the last example, into two major-classes: the one comprising all trees of 10—11½ inches diameter, and the other those of 12—13.

There would then be for the former major class:—

100	trees of	10 in.	diam.	with a sum of	basal areas of	54·5	sq. ft.
200	„	10½	„	„	„	120·2	„
250	„	11	„	„	„	155·0	„
180	„	11½	„	„	„	129·78	„
730	trees with total basal area of					469·48	„

Therefore, the average basal area of one tree is $\frac{469 \cdot 48}{730} = \cdot 643$ square feet, which corresponds to a diameter of 11 inches. The diameter of the sample-tree for the first major class is, therefore, 11 inches.

The second major class would consist of

200	trees of	12 in. diam.	with a total	basal area	of	157·00	sq. ft.
140	"	$12\frac{1}{2}$ "	"	"	"	119·28	"
130	"	13 "	"	"	"	119·86	"
470						396·14	"

And the average basal area of a tree for it would be $\frac{396 \cdot 14}{470} = \cdot 843$ square feet, which corresponds to a diameter of 12·5 inches.

If the averages of the sample-trees felled contain, say, for the first class, 11·31 cubic feet, and for the second 12·9 cubic feet, then the contents of the whole group would be

$$730 \times 11 \cdot 31 + 470 \times 12 \cdot 9 = 14319 \cdot 3 \text{ cubic feet.}$$

In this example it is assumed that the group is unmixed. If it were mixed it might be necessary to estimate the yield of each species separately.

It is advisable to fell a fixed percentage of sample-trees of each major class: $\frac{1}{4}$ to 1 per cent. will suffice for ordinary purposes. The latter rate, in the above example, would give seven sample-trees for the first and five for the second. A larger relative number is sometimes taken for classes comprising the larger trees.

In selecting sample-trees, trees should be chosen which appear to be representative of their class as regards height and crown, and which have a circular (not elliptical) trunk. If a suitable tree of exactly the required diameter is not to be found, another of nearly the same diameter may be taken instead, and the cubic contents of a proper sample-tree deduced from its volume. In that case, if V is the volume and d the diameter of the proper sample-tree, V' and d' the corresponding dimensions of the tree actually measured, V would be found by the proportion

$$V : V' :: \frac{\pi}{4} d^2 h . f . : \frac{\pi}{4} d'^2 h' f'$$

When h, f, and h', f', represent the heights and form-coefficients of the trees respectively. Since, however, their heights and co-efficients must be very nearly alike, h, f, may be put equal to h', f', when the proportion becomes

$$V : V' :: \frac{\pi}{4}d^2 : \frac{\pi}{4}d'^2$$

Whence $$V : V' :: d^2 : d'^2$$

or $$V : V' :: a : a'$$

when a and a' are the basal areas of the trees, respectively. Therefore,

$$V = V' \frac{d^2}{d'^2}$$

or $$= V' \frac{a}{a'}$$

The details of the estimate may be tabulated in the following form :—

Particulars of Sample-Trees.					Number of trees in each major class.	Particulars of Group		
Age.	Height to outermost branches. Feet.	Mean diamtr. Inches.	Major class. Inches.	Cubic contents. Feet.		Cubic contents. $f \times g$ Feet.	Estimated centage c Timber.	C v
f	*c*	*d*	*e*	*f*	*g*	*h*	*i*	
30	30	11	10–11½	11·50				
„	34	„	„	12·65				
„	28	„	„	10·59				
„	29	„	„	10·50				
		To	tal ...	45·24				
rage	contents	of one	tree.	11·31	730	8256·3	85	•
„	31	12·5	12–13	13·02				
„	33	12·5	„	12·78				
				25·80				
rage	contents	of one	tree	12·90	470	6063·0	85	

and so on for the remaining classes.

The percentage of timber and firewood is calculated on the average yield of the several sample-trees. For this reason, it is perhaps advisable to divide column *f* into two sections, the one showing the yield of timber, the other of firewood.*

In order to avoid the necessity of estimating the trees of each class separately, the number of sample-trees for a class may be made to bear a fixed proportion to the number of trees in such class.† Supposing, for instance, that a uniform percentage, p, of sample-trees is taken: that the number of trees in the group is n, and the number of trees in the several diameter classes n_1, n_2, n_3, &c., there will then be of sample-trees for each class:—

$$n_1 \times \cdot 0p, \quad n_2 \times \cdot 0p, \quad n_3 \times 0 \cdot 0p, \text{ \&c.}$$

Let us take, for example, a group consisting of the following trees:—

Diameter-class. Inches.	Number of trees.	Corresponding basal area of one tree. sq. ft.	Sum of basal areas b × c. sq. ft.
a	*b*	*c*	*d*
10	100	·545	54·5
10½	200	·601	120·2
11	250	·661	165·0
11½	180	·721	129·78
12	200	·785	157·00
12½	140	·882	119·28
13	130	·992	119.86
	1200		865·62

* There seems to be no convenient English term equivalent to the French *bois de travail*, or to the German *Nutzholz*. The word *timber* is generally, I think, used as meaning large building-wood. We want a term which will include wood used for any constructive purpose: such as for toys, cabinets, &c. Perhaps the term *log-wood*, or *wood in log*, might answer, in contradistinction to firewood, which is not sold in logs.

† First proposed by Draudt in his *Die Ermittlung der Holzmassen*.

If, now, we fell 1 per cent., we shall require altogether 12 sample-trees, distributed among the classes as follows :—

For the class 10 inches $\frac{12 \times 100}{1200} = 1\cdot0$ sample-tree

" $10\frac{1}{2}$ " $\frac{12 \times 200}{1200} = 2\cdot0$ "

" 11 " $\frac{12 \times 250}{1200} = 2\cdot5$ "

" $11\frac{1}{2}$ " $\frac{12 \times 180}{1200} = 1\cdot8$ "

" 12 " $\frac{12 \times 200}{1200} = 2\cdot0$ "

" $12\frac{1}{2}$ " $\frac{12 \times 140}{1200} = 1\cdot4$ "

" 13 " $\frac{12 \times 130}{1200} = 1\cdot3$ "

As we cannot examine fractions of sample-trees, it is necessary to round off these figures, a procedure which will make no practical difference in the general result. We shall then get

For 10-inch class	1 sample-tree
$10\frac{1}{2}$ "	2 "
11 "	3 "
$11\frac{1}{2}$ "	2 "
12 "	2 "
$12\frac{1}{2}$ "	1 "
13 "	1 "
	12

If we had not already the full complement of trees, we might, by forming the $12\frac{1}{2}$ and 13-inch classes into one class, have made these classes together amount to 2·7, which, when rounded off, would have given three trees for these two classes instead of only two. Having, however, got the full number without doing

this, it is better not to increase the number in the present case. It is always advisable to resort to this device for completing the percentage whenever it can be conveniently accomplished.

Having determined the diameters of the model-trees, in the manner already described, and selected corresponding trees in the group, we may determine their cubic contents, either by measuring them separately, as before, or all together. In the latter case, the portions of the trees which are disposed of in stacks are worked up all together into stacks, and their cubic contents deduced by one of the methods already described. One of the chief merits of Draudt's method is that it admits of all sample-trees being worked up together.

The particulars of the estimate and measurements are then noted down in the following form :—

PARTICULARS OF SAMPLE-TREES.

Serial No.	Diameter-class.	Number of trees.	Basal area of one tree.	Sum of basal areas c × d.	Height.	Age.	CONTENTS.		
							Timber.	Firewood.	Total h + i.
	Inches.		Sq. ft.	Sq. ft.	Feet.		Cubic ft.	Cubic ft.	Cubic ft.
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*k*
1	10	1	·545	·545	30	30	9·87	1·63	11·50
2	10½	2	·601	1·202	34	„	21·50	3·80	25·30
3	11	3	·660	1·980	28	„	27·03	4·77	31·80
4	11½	2	·721	1·442	29	„	17·84	3·16	21·00
5	12	2	·785	1·570	31	„	22·10	3·90	26·00
6	12½	1	·882	·882	33	„	10·88	1·92	12·80
7	13	1	·922	·922	35	„	14·60	2·40	17·00
				8·543			123·82	21·58	145·40

To find the contents of the group, let *M* represent its cubic contents, *m* that of the sample-trees, *A* the

sum of the basal areas of all trees in the group, a that of the sample-trees. We shall then have the proportion

$$M : m :: A : a$$

and, therefore, $$M = \frac{A}{a} m$$

In the present case

$$A = 865{\cdot}62 : \quad a = 8{\cdot}543 : \quad m = 145{\cdot}4.$$

Therefore $$M = \frac{865{\cdot}62}{8{\cdot}543} \times 145{\cdot}4 = 14784{\cdot}6$$

or, if we wish to find the timber and firewood separately, the timber alone will amount to

$$\frac{865{\cdot}62}{8{\cdot}543} \times 123{\cdot}82 = 12590{\cdot}3$$

and the firewood to

$$\frac{865{\cdot}62}{8{\cdot}543} \times 21{\cdot}58 = 2194{\cdot}3$$

The correctness of Dr. Draudt's method is evident from the following considerations:—Supposing that all trees of a group are comprised in one class with one average tree, we would then have

$$M = \frac{A}{a} m.$$

But suppose that, instead of this one class, separate classes are constituted, namely,

$$\frac{A_1}{a_1} m_1, \quad \frac{A_2}{a_2} m_2, \quad \frac{A_3}{a_3} m_3, \text{ \&c.}$$

If, now, n_1, n_2, n_3, &c., represent the number of trees of each class, respectively, a_1, a_2, a_3, &c., the basal areas of the average trees of each class, respectively, then will

$$A_1 = a_1 n_1 : \quad A_2 = a_2 n_2 : \quad A_3 = a_3 n_3 : \text{ \&c.}$$

and, since the number of sample-trees is proportional to the number of trees,

$$a_1 = a_1 n_1 p \ : \ a_2 = a_2 n_2 p \ : \ a'_3 = a_2 n_2 p \ : \ \&c.$$

and $$\frac{A_1}{a_1} = \frac{a_1 n_1}{a_1 n_1 p} \ : \ \frac{A_2}{a_2} = \frac{a_2 n_2}{a_2 n_2 p} \ : \ \frac{A_3}{a_3} = \frac{a_3 n_3}{a_3 n_3 p} \ : \ \&c.$$

Therefore

$$A_1 : a_1 :: 1 : p; \ A_2 : a_2 :: 1 : p; \ A_3 : a_3 :: 1 : p; \ \&c.$$

But $$A : a = 1 : p$$

Therefore $$\frac{A}{a} = \frac{A_1}{a_1} = \frac{A_2}{a_2} = \frac{A_3}{a_3} = \&c.$$

And, since $$M = \frac{A}{a} m,$$

$$M = \frac{A}{a} m_1 + \frac{A}{a} m_2 + \frac{A}{a} m_3 + \&c.$$

$$= \frac{A}{a} (m_1 + m_2 + m_3 + \&c.)$$

and $$m = (m_1 + m_2 + m_3 + \&c.)$$

As already observed, one of the chief merits of Draudt's method is, that sample-trees can be worked up *all together* into stacks, whose contents may then be deduced from known results of the solid contents of stacked wood. When the contents of each tree have to be calculated separately, there will seldom be enough material in each single case to fill up standard stacks of the several descriptions of amorphous wood, and the laborious process of indirect measurement, described at page 96 will have to be resorted to, whereas, when there are a number of sample-trees, it will generally be possible by Draudt's method to get a sufficient quantity of stacked material of every de-

scription to make reliable quantitative deductions from previous experiments. Stacking the wood and deducing its contents from known results, is generally preferable to deducing the number of stacks from the solid contents of the wood, because, in the latter case, if the stack-coefficients are not accurately determined, the number of stacks actually obtainable from a group will not tally with the estimated number; but the two will correspond if the converse method is followed, provided, of course, that the sample-trees represent the proper relative quantity of wood.

A further advantage of this method is, that it shows the relative proportion of wood of all descriptions of a group, a factor on which the value of forests greatly depends. It is often not so much on quantity as on quality that the value of wood in a group depends; and it is, therefore, very important to fix the quantity of each description as accurately as possible.

Draudt's method may be advantageously employed for all systems of estimating the cubic contents of groups which require the felling of sample-trees, and the diameter-measurements of all trees on the area examined.

(2). Methods of Determining the Contents of Groups by means of Form-Coefficients.

As we already know, the contents of a tree may be found by multiplying together its height, basal area, and form-coefficient.

Similarly, we may find the cubic contents (m) of a group by multiplying together its average height (h), the basal area of an average tree (a), the average

co-efficient of form (f), and the number of trees (n); that is

$$M = n \,.\, a \,.\, h \,.\, f.$$

or if $n \,.\, a \,.$ is put equal to A,

$$M = A \,.\, h \,.\, f.$$

The sum of the basal areas may be determined by means of diameter-classes, in the way already described, and we shall then have

$$A = n_1 a_1 + n_2 a_2 + \ldots + n_n a_n$$

The mean height of the group would be found by measuring the heights of all the trees, and dividing their sum by the number of trees, but this would, of course, be too laborious a process for actual practice. It is usual, therefore, to assume that the trees—presumably all of about the same age—are all of the same form. We should in that case have

$$Ahf = f(n_1 a_1 h_1 + n_2 a_2 h_2 + \ldots + n_n a_n h_n)$$

Whence

$$h = \frac{n_1 a_1 h_1 + n_2 a_2 h_2 + \ldots + n_n a_n h_n}{A}$$

Here $A = n_1 a_1 + n_2 a_2 + \ldots + n_n n_n$

Therefore $h = \dfrac{n_1 a_1 h_1 + n_2 a_2 h_2 + \ldots + n_n a_n h_n}{n_1 a_1 + n_2 a_2 + \ldots + n_n a_n}$

The above formula is the one generally used for this purpose, and that is the only reason for mentioning it here, as it does not appear to be of any real value. If it be assumed that the forms and ages of all the trees are the same, it may also be taken for

granted that their heights are the same, and in tha case we should have

$$h = \frac{(n_1 a_1 + n_2 a_2 + \ldots\ldots + n_n a_n)\, h}{n_1 a_1 + n_2 a_2 + \ldots + n_n a_n}$$
$$= h,$$

which is equivalent to saying that the mean height is equal to the mean height, a fact which is certainly true, but which, unfortunately, brings us no nearer a solution of the problem than we were at starting.

If all the diameters of the trees in a group are to be measured, Draudt's is probably the best way of finding the height of the average tree; and when more than one sample-tree is felled, the sum of the cubic contents of all sample-trees, divided by their basal areas, will give the mean height. If his method is to be followed, we have in it the very best way of estimating the average height or co-efficient of a group, and do not need to look about for other means.

When less accurate means will suffice, a number of trees of apparently average height may be measured, and their average height taken as a mean of the group. With regard to the question of accuracy, it should be remembered that the correct determination of heights is not nearly of so much importance as the correct determination of the diameters. A tree 18 inches in diameter, with a co-efficient ·5, and height of 70 feet, would contain 60·9 cubic feet. Supposing, now, that its diameter were wrongly estimated at 18½ inches, but the height rightly estimated, its contents would then amount to 65·4 cubic feet. Supposing, again, that the diameter was correctly estimated, it would require an estimate of height

exceeding the actual height of the tree by 4 feet, for the contents to amount to 65·4 feet; or an error in the measurement 96 times greater than in the former case.

For most practical purposes in which this method is employed, the average co-efficient of form may be estimated by felling and measuring a few apparently average trees, or by inference from average results obtained under similar circumstances elsewhere. The latter method is preferable if applied to the valuation of a considerable number of trees, provided that the co-efficients were obtained on the average results of a great number of trees growing under similar conditions of age, height, and density. The felling of sample-trees is thus avoided, and much time saved.

The method of co-efficients is a favourite one with some foresters; but it is to be preferred to the preceding methods only on account of its more rapid execution; in other respects it is far inferior to them.

König's table of co-efficients for Scots' pine and larch are given below. He gives five classes: 1. For sickly trees, growing up crowdedly, in poor stations. 2. For tolerably dense groups, in good condition. 3. For more open groups of trees, with good crowns, and long full boles. 4. For open groups; trees with fuller crowns, more spreading, and more thickly branched.

*Table of Co-efficients of Form for Scots' Pine and Larch, exclusive of Branches (König).**

Height of Tree.	I.	II.	III.	IV.
10	0·491	0·531	0·590	0·666
20	0·486	0·526	0·584	0·660
30	0·481	0·521	0·579	0·653
40	0·476	0·516	0·573	0·646
50	0·471	0·511	0·567	0·640
60	0·467	0·507	0·562	0·633
70	0·463	0·503	0·557	0·627
80	0·458	0·498	0·552	0·620
90	0·453	0·493	0·546	0·613
100	0·449	0·489	0·541	0·607
110	0·445	0·485	0·536	0·600
120	0·440	0·480	0·530	0·594
130	0·435	0·475	0·525	0·587
140	0·430	0·470	0·520	0·580

Method of Determining the Cubic Contents of Groups by means of Tables showing the Contents of each Tree, singly.

In 1846, the Bavarian Government published tables† showing the contents of trees of the principal forest species according to their ages, heights, and diameters at 4½ feet from the ground. They were constructed with the object of avoiding the necessity

* *Forsttafeln zur Ausmessung Gehalts- und Werthschätzung aufbereiteter Hölzer, &c.*

† *Massentafeln zur Bestimmung des Inhalts der vorzüglichsten teutschen Waldbäume, &c.*

of felling and measuring sample-trees in order to estimate the contents of groups.

These tables are based on the assumption that trees of the same height, diameter, and about the same age, will have the same co-efficient, and, consequently, the same cubic contents.

The data for the preparation of the tables were collected from all parts of the kingdom of Bavaria. Altogether, 40,220 trees* were felled and measured, and the following particulars regarding each tree ascertained :—

(1). The diameter, at 4½ feet from the ground, to 10ths of an inch.

(2). The length of the tree in feet to the tips of the highest branches.

(3). The age of the tree.

(4). The cubic contents of the bole.

(5). The cubic contents of the branches.

(6). The whole contents of the tree (branches and bole together).

(7). The product of basal area multiplied by height of tree.

(8). The co-efficient of form.

The boles were cubed in sections not exceeding 10 feet in length, and treated as frustums of a paraboloid, the ends being treated as circles and their diameter determined to one tenth of an inch.

The following plan was adopted in constructing the tables :—

(1). Age-classes, comprising all trees from 1—30,

* The details of the fellings are : Spruce 21,780 trees ; silver fir, 4,500 ; Scots' pine, 4,280 ; larch, 590 ; beech, 3,710 ; oak, 2,490 ; birch, 2,870. Total, 40,220.

31—60, 61—90, &c., years old, were formed; also height-classes proceeding by differences of 10 feet, and diameter-classes by differences of one inch. For each of these diameter and height classes, the average co-efficient of form was calculated. Supposing, for instance, there were altogether three trees of the class "1—30 years old, 20—30 feet high, and diameter 4 inches," and that these trees had co-efficients of ·6, ·7 and ·5 respectively; the average co-efficient for all trees 1—30 years old, 20—30 feet high, and 4 inches in diameter, would be

$$\frac{\cdot6 + \cdot7 + \cdot5}{3} = \cdot6.$$

(2). If the co-efficients of two or more classes happened to be about the same, their mean values were taken as those of each such class.

(3). The ratios of the co-efficients to one another were then compared, and any extremes or obvious irregularities corrected. This regulation was effected by the method of curves.

(4). The contents of a tree of a given height and class was found by multiplying its corrected class-coefficient by its height and by its basal area.

As trees of the same diameter and height may differ considerably in age, separate sets of tables had to be constructed, viz., for trees aged, respectively, from 1—30, 31—60, 61—90, 91—120, &c.

It appears from the results of these experiments :—

(1). That the relative values of the co-efficients of the species examined are, in descending order :—

1. Beech (highest).
2. Oak.
3. Silver Fir.

4. Spruce.
5 Scots' Pine.
6. Larch.
7. Birch (lowest).

(2). That the co-efficients of all species increase in magnitude with the age of the tree; that the height and diameter of two trees of different ages being the same, but their ages different, the younger will have the smallest co-efficient.

(3). That the ages being the same, increased diameter or height sometimes affects the co-efficient one way, sometimes another.

In the case of oak and beech, the co-efficient varied in the same direction as the diameter; with silver fir, larch, and spruce, the contrary effect was observed; while in the case of pine and birch no decided effect was perceptible.

With relatively greater height, the co-efficients became less with oak, beech, birch and pine; whilst with larch, silver fir, and spruce, there was no perceptible increase.

The tables are drawn up in the following form for each age-class :—

Spruce 61—90 years old.

Height feet.	Diameter inches.										
	4	5	6	7	8	9	10	11	12	13	etc.
	Cubic contents, feet.										
20	1·4	1·9	2·9	...	...	...	...	...	...	...	&c.
21	1·5	2·1	3·0								
22	1·5	2·3	3·1								
23	1·6	2·4	3·2								
24	1·6	2·5	3·3								
25	1·7	2·6	3·4	4·5	5·6	6·8					
					etc.						

and in the same way for other age-classes. In the case of some species, the figures give the contents of the whole tree, in others only the contents of the bole.

Before using the tables to determine the contents of a group, it is of course necessary to determine approximately its average age. This may be done by felling a few average-sized trees and counting the annual layers; or, if the group is tolerably regular, it may in many cases be estimated by eye, or from stumps, as a considerable margin of error is admissible.

The average height of the trees for each diameter-class must also be fixed.* To determine the height for a class, a few trees are selected of the required diameters, measured with the hypsometer, and their mean height taken as the height of the class. These mean heights for each class may then be represented graphically, and irregularities eliminated by curves in the manner already described.

As the Bavarian tables were the result of averages obtained from fellings on a large scale in different parts of the kingdom, it follows that they should be used to estimate the cubic contents of trees only when a considerable number have to be measured. They cannot be relied upon in the case of single trees, but surprisingly accurate results have been invariably obtained by their use in estimating masses of forest. Before being issued to forest officials in Bavaria, they were thoroughly tested on 18,424 trees of all kinds,†

* See also Section V., p. 148.

† Namely, spruce 5,426, measuring 344,832 cubic feet; silver fir 4,483, measuring 349,924 cubic feet; oak 2,028, measuring 162,336 feet; beech 1,743, measuring 74,496 feet; Scots' pine 1449, measuring 58,104 feet; birch 2,741, measuring 28,800; larch 554, measuring 8,544 feet.

measuring 1,026,144 cubic feet. The maximum error was found to have been made in the case of spruce, for which the estimate amounted to 1·15 per cent. too much; the minimum error was made in the estimate of Scots' pine, amounting to ·32 per cent. too much. The mean error amounted to ·017 per cent.

Subsequent experiments on 18,000 other trees gave equally favourable results, and a mean error of ·02 per cent. for the whole series made in Bavaria. In Würtemberg, experiments on 1,340 trees of different kinds, measuring 52,278 cubic feet, gave a mean error of ·003 per cent.

Experiments carried out in Prussian forests, by order of Government, show a mean error of 1·8 per cent. in the contents of 70,546 trees of different kinds.

Other experiments, equally favourable, have been made in the other parts of Germany, and there cannot be the slightest doubt that tables constructed on this principle are perfectly reliable for estimating the contents of groups, and that where very considerable numbers of trees are examined, no other method is likely to give as satisfactory results.

The secret of this extraordinary applicability to various conditions no doubt lies in the system of classification adopted. Only trees of nearly the same height, diameter, and age were grouped together. In this way the principal factors on which the form of a tree depends were classified, so that only trees of the same form should come under the same set of tables.*

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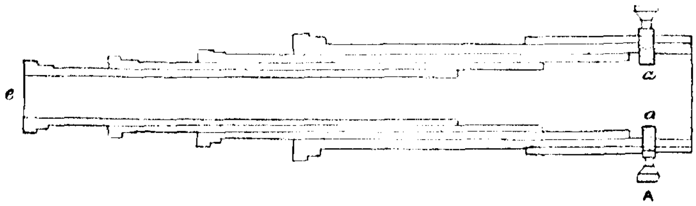
* It would be interesting to know if these tables could be used to estimate the contents of groups in the United Kingdom. I am confident that they would give results as satisfactory as those cited above.

IV.—Pressler's Method of Estimating the Contents of Standing Trees.

Pressler has discovered a very simple method by means of which he proposes to measure the boles of standing trees.* His plan is to find that point of the stem at which the diameter is half that of the basal diameter. The solid contents of the tree, supposing that its shape is that of a paraboloid, will then be determined by multiplying the distance from the ground of the point thus found by half the basal area.

To find the position of this point he has invented an instrument in the form of a telescope. *a*, *a*,



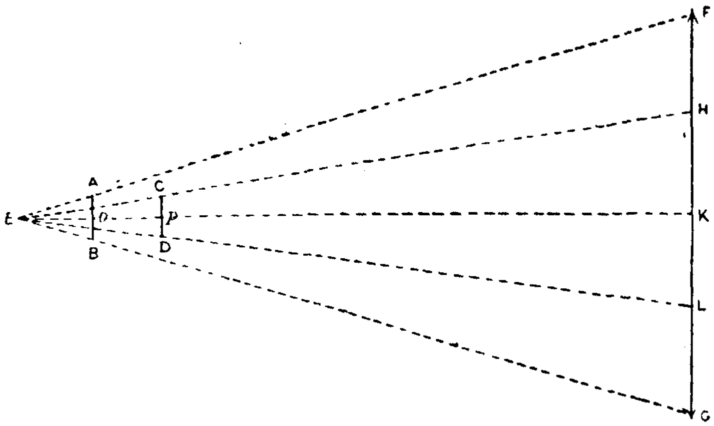
Vertical section of Pressler's instrument.

are pins, which can be shortened or lengthened by turning the screws *A*, *A*. The instrument can be lengthened and shortened in the same manner as an ordinary telescope. To use it the observer looks through the eye-piece, *e*, at the point of the tree just above the buttressed part of the trunk where the lower diameter is usually measured, arranging the screws so that the stem appears to occupy exactly the space between the points of the pins. The telescope is then drawn out to double its former length, again put to the eye, and the point of the tree at which the stem

* *Das Gesetz der Stammbildung*, &c.

appears to fit exactly between the two pins observed, and its height above the ground measured with a hypsometer. If the instrument is accurate and the operation correctly performed, the diameter of the tree at the point thus found will be just half the basal diameter.*

* Let E be the eye-piece ; $A\,B$ the apparent diameter of an object $F\,G$, as observed through the telescope when drawn out to a distance, $E\,o$. Without altering the position of the instrument, advance the objective, $A\,B$, to $C\,D$, so that $E\,p = 2\,E\,o$. Draw $E\,K$ at right-angles to $A\,B$ and $C\,D$.



In the similar triangles, $E\,A\,B$, $E\,F\,G$, we shall then have

$$\frac{E\,o}{A\,B} = \frac{E\,K}{F\,G} \quad \ldots\ldots\ldots \quad (1)$$

and in the similar triangles, $E\,C\,D$, $E\,H\,L$,

$$\frac{C\,D}{E\,p} = \frac{H\,L}{E\,K}$$

or since $E\,p = 2\,E\,o$, and $A\,B = C\,D$,

$$\frac{A\,B}{2\,E\,o} = \frac{H\,L}{E\,K} \quad \ldots\ldots\ldots \quad (2)$$

multiplying (1) by (2) we get

$$\tfrac{1}{2} = \frac{H\,L}{F\,G}$$

or $$\tfrac{1}{2}\,F\,G = H\,L.$$

The practical value of this method has not been sufficiently investigated. So far as is yet known, it appears to give fairly accurate results, even with the instrument as at present constructed, which might be considerably improved, if made of brass and furnished with properly fitting screws, in place of the present pasteboard arrangement. Judeich found a mean error of −1·08 per cent. in calculating the contents of 22 spruce boles, and Schaal of −·28 for 300 stems, of which 250 were deciduous trees.

An objection to employing the instrument is that the branches have to be estimated on average results of former cuttings, or by eye. A further objection is that the position of the half-diameter is not easy to determine, and sometimes, owing to the forking of the branches, cannot be determined at all; and probably these are the reasons why it has not found favour with practical men.

V.—Employment of Size-Classes and Height-Classes in the Determination of the Contents of Groups.

It is seldom that groups are so regular that one height-class will suffice. It is usual, therefore, in irregular forests, to have two or more height-classes. One of two plans may be adopted in determining the height-classes. Either one average height is determined for each or several diameter-classes, or the assessor when measuring the diameters estimates the height-classes to which the trees belong, and enters them accordingly in the field-book.

By the former method, a few average-sized trees are selected, their heights measured, and the mean taken

as the height of all trees of the class. The heights so obtained may be recorded in the following form of field-book :—

Diameter classes.	Scotch Pine. Heights.				Spruce. Heights.				Larch. Heights.			
Inches.	60 feet.	70 feet.	80 feet.	Average feet.	60 feet.	70 feet.	80 feet.	Average feet.	70	80	90	Average feet.
10–11	1111	1	11	67	11		1	66	11	1		73
11–12	11	111	1	68	1	1	1	70				
12–13		1	1	75		1	1	75		1	1	85

The average heights may be represented graphically and irregularities eliminated if necessary.

When the method adopted for determining the contents of the group involves the felling of sample-trees, as, for example, Draudt's method, the height of the sample-trees will be the best guide to the average heights of the diameter-classes to which they belong.

By the second method the assessor, as already observed, estimates by eye the class to which a tree belongs when measuring the diameter. This is a fatiguing and troublesome operation, and two, or at most three, classes are as much as he can manage.

The form of field-book given at page 124 will have to be altered in this case to the following, supposing there are two height-classes :—

Diameter.	Scotch Pine.				Spruce.				Larch.			
	1st height class.	Total.	2nd height class.	Total.	1st height class.	Total.	2nd height class.	Total.	1st height class.	Total.	2nd height class.	Total.

Average-stems of each class are then searched out and measured by one of the methods already described, and their means taken as the height of their respective classes.

It will suffice in most cases if the height-classes have a range of 10 to 15 feet. This point, and the number of classes to be formed, will depend on the degree of irregularity of the forest and the accuracy required. As a rule, two, three, or at most four classes will suffice. As few as are compatible with the degree of accuracy required should be employed, as the labour of assessment is greatly enhanced by taking a large number.

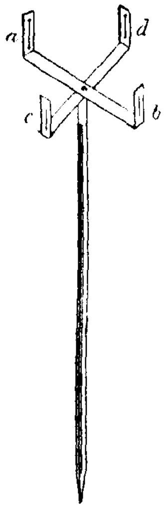
C.—Methods involving Diameter-Measurements of only a Portion of the Trees.

VI.—By means of Sample-Areas.

By this method, only a portion of the group or forest is measured, and the contents of the remainder deduced from the result. The methods employed in

estimating the contents of a portion of forest are the same as those already described for estimating the contents of whole groups.

In choosing a sample-area, care must be taken to select a piece of forest which is representative of the whole. On hill-sides, for instance, it would not do to take the lowest-lying portion nor the highest; the estimate would probably be too high in one case and too low in the other; the sample-area should be taken, as a general rule, somewhere between the two extremes. A better plan, especially for large expanses of forest in which average portions cannot be easily determined, is to select several plots in various situations.



The most convenient shape for a plot is the square. It will often, however, be advisable to choose an elongated strip, in irregular forests; if the plot is well chosen, that form is generally more likely to enclose an average section of the forest.

The right angles of the rectangle may be quickly fixed by means of the little instrument shown in the accompanying figure.

At the end of a staff, $4\frac{1}{2}$ feet long, two brass arms, *ab* and *cd* at right-angles to each other, and with ends bent at right-angles to their lengths, are fixed. The centres of the upturned ends of the arms have slits, each containing a fine vertical wire. To use the instrument, it is set up vertically at a corner of the plot to be measured, and the wires of one arm, *ab*,

aligned in the direction of one side of the plot. The line joining the wires of the other arm is then, of course, pointing in a direction at right angles to *ab*, and by its means the adjacent side may be projected, and so on for the remaining sides.

As a rule, not less than three-quarters of an acre should be taken as a sample-area.

The cubic contents of the sample-plot and its area being known, the cubic contents of the whole group will be found by the proportion

$$c' : c = a' : a$$

When c' = the contents of the whole group,
c = that of the plot,
a' = the area of the whole group,
a = that of the plot,

Whence $$c' = \frac{a' \times c}{a}$$

The marking-off of sample-plots is a slower process than might be supposed, and it will often be possible to estimate the contents of a small group of known area as quickly as a plot of unknown area half its size.

Choice of a Method.

This will depend mainly on the degree of accuracy required, the value and kind of forest, and the time and staff available for the work.

Practical men are agreed that the contents of exploitable groups, and those approaching exploitability should be determined with the greatest degree of accuracy circumstances admit. All groups, therefore, which are within 15–20 years of maturity should

be carefully measured; for younger groups less accurate methods will suffice. For irregular seedling groups which are exploitable, or nearly so, it is desirable to adopt one of the methods involving the diameter-measurements of all trees with height-classes, and on Draudt's system, or tables constructed on the principle of the Bavarian tables may be used. Regular old groups, on the other hand, may be treated by less laborious methods; by dispensing with all but one height-class, or by the still more rapid process of sample-areas.

The measurement of each tree may seem a very formidable affair at first sight. It must be remembered, however, that in old seedling-forest there are comparatively few trees to the acre, and that three men —namely, two diameter-measurers and one clerk—can measure per diem, according to Kunze, the diameters of 5,000 to 6,000 mature trees when there are 250 to 300 to the acre, or about 690 trees per working hour, provided the ground is clear of underwood.*

The contents of younger groups may be calculated by the method of sample-areas, or by means of experiential tables. It is not possible to measure the youngest groups stem by stem, on account of their great density, and if there are no experimental data to go by, the best plan is to measure off small sample areas, to cut down and stack all the material on them, and to calculate the solid contents of the yield on data obtained by the experimental testing of the solid contents of stacked wood. These experiments may

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* *Lehrbuch der Holzmesskunst*, p. 235. Hess and Baur arrived independently of each other, at much the same results as Kunze.

be made on the spot, or the results of former experiments may be utilized.

This is also the best method of determining the contents of coppice, whose standing stock may generally be calculated from the mean yearly yield of the normal annual cutting.

Overwood should, if possible, be estimated by means of height-classes, diameter-classes, and sample-trees for each class.

6. Determination of the Average Age of Groups.

It is of great importance to determine this point correctly. If it is wrongly determined, the estimated mean yearly increment will be wrong, and consequently all calculations, such as the length of the revolution, the quality of the groups, stations, and age-classes which happen to be based on it, will also be wrong.

In regular forests, that is to say, in groups in which the trees are all of about the same age and height, which will generally be the case in those which have originated artificially, it will suffice to fell and count the annual layers of one of the (larger) trees. In coppice it will often not be absolutely necessary to fell specially any trees, as, on account of the shortness of the revolution, the age can sometimes be determined with sufficient accuracy without resorting to fellings. Again, the age of Scots' pine and one or two other conifers can often be told by counting the number of branch-whorls. In those cases in which a record of the formation of a group has been kept its age will, of course, be most accurately fixed by such record. In estimating the age of felled trees by counting the

annual layers, an allowance must be made for the length of the stump. Before counting the layers it will generally be necessary to smooth the surface of the stump with a plane. If the layers do not even then stand out distinctly, an application of very diluted ink or (blue) starch and the use of a magnifying glass may have the desired effect. The rings are counted in tens. As soon as ten have been counted, they are marked off with a pencil; the next ten are treated in the same way, until the whole number are echeloned from centre to circumference. By this means mistakes of addition are easily avoided.

In considering the case of an irregular group it must be borne in mind that the question to solve is, what the age of a regular group would be whose cubic contents are equal to the cubic contents of the irregular group under examination. For thoroughly satisfactory determinations, therefore, it is necessary to estimate the cubic contents of the group. If Draudt's method is employed, the average age in the above sense will evidently be obtained by counting the annual layers of the sample-trees and dividing their sum by the number of such trees. By this method the determination of cubic contents is confined to the sample-trees.

A method frequently employed is to estimate the mean yearly growth, and deduce from it the average age of the group. If A is the average age of a group, M its cubic contents, I its increment, the mean yearly increment will evidently be found by the equation

$$I = \frac{M}{A}$$

From which we get $A = \frac{M}{I}$

Supposing, for example, that a group consists of a number of age-classes with cubic contents, m_1, m_2, m_3 &c., and ages, n_1, n_2, n_3, &c., respectively. The mean increment of each age class will be $\frac{m_1}{n_1}, \frac{m_2}{n_2}, \frac{m_3}{n_3}$, respectively. But the mass of the whole group, M, is equal to $m_1 + m_2 + m_3$, &c.; therefore,

$$A = \frac{m_1 + m_2 + m_3 + \&c.}{\frac{m_1}{n_1} + \frac{m_2}{n_2} + \frac{m_3}{n_3} + \&c.}$$

Or
$$A = \frac{a_1 h_1 f_1 + a_2 f_2 h_2 + a_3 h_3 f_3 + \&c.}{\frac{a_1 h_1 f_1}{n_1} + \frac{a_2 f_2 h_2}{n_2} + \frac{a_3 f_3 h_3}{n_3} + \&c.}$$

When a_1, a_2, a_3, &c., represent the basal areas of each class, respectively, f_1, f_2, f_3, &c., the co-efficients, and and h_1, h_2, h_3, &c., the heights.

If the heights and co-efficients of all classes are alike—certainly not a very probable contingency—the formula becomes:

$$A = \frac{a_1 + a_2 + a_3 + \&c.}{\frac{a_1}{n_1} + \frac{a_2}{n_2} + \frac{a_3}{n_3} + \&c.}$$

7. Determination of the Increment of Groups.

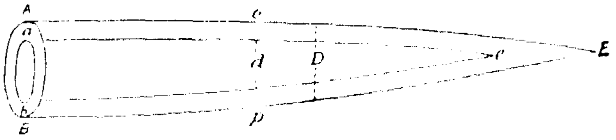
All methods of organization require a more or less accurate determination of the increment, as we shall see when we come to an examination of the different systems of determining the annual yield.

The increment of a group may be determined (1) by measuring the increment of sample-trees, (2) by experiential tables, (3) by means of tables constructed on the plan of the Bavarian tables.

Determination by means of Sample-Trees.

The sample-tree, or trees, having been selected by one of the methods already described, we may find its growth during the past year by deducting the volume of the tree (without bark) as it was a year ago from its present volume.

If, in the accompanying figure, *ABE* represents the



present volume of a tree, *abe* its volume a year ago, the last year's growth will be equal to *ABE*—*abe*.

The volume of *ABE* may be found by multiplying the area of the circle corresponding to its diameter at half the distance from its base, by its length, on the assumption that the tree is a paraboloid. Or if *D* represents the diameter at the centre of the tree, *C* the cubic contents of the tree, *H* its height.

$$C = \pi \left(\frac{D}{2}\right)^2 H = \cdot 7854 . D^2 . H.$$

Similarly, if *d* represents the diameter of *abe* at half its length, and *h* its length, its volume will be

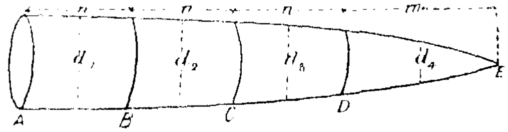
$$\pi \left(\frac{d}{2}\right)^2 h = \cdot 7854 . d . h.$$

Therefore

$$ABE - abe = \cdot 7854 . D^2 . H - \cdot 7854 . d^2 . h.$$

When great accuracy is essential, the trunk may be divided into sections, and each one cubed separately.

In the accompanying figure, each of the sections *AB*, *BC*, *CD*, may be regarded as the frustum of a paraboloid, and *DE* as a paraboloid. If the areas of the ends of a frustum are M and N, respectively, and its length n, its cubic contents will be $\frac{n}{2}$ $(M + N)$, and the contents of each section may, therefore, be found by this formula. But a simpler and better plan is to measure the area of a circle corresponding to the diameter of the frustum at half its height. If M represents the area at that point, the contents of the frustum will be $M \times n$.



If the sections are all of the same length, and the areas corresponding to their diameters at the centre are M_1, M_2, &c., the contents of the whole tree will evidently be equal to $n\,(M_1 + M_2 +$ &c.). The terminal section *DE* would in most cases not be equal in length to the others, in which case it would have to be estimated separately. The contents of *ABE* (*see* fig., p. 157) may be quickly found in this manner, but it is an extremely laborious process for finding the contents of *abe*, necessitating the cutting up of the tree into pieces at d_1, d_2, &c., (fig. 2).

The growth of one year is so small that it is very difficult to measure. For this reason, and in order to obtain a more average result, it is usual to measure

the growth of 10 or more years at once, and to take the mean as the current growth of a year.

In order to find the length of the paraboloid, *abe*, (*see* figure, p. 157), we must deduct *eE* from *AE*. If the difference in age between *ABE* and *abe* is 10 years, it will, for example, be necessary to deduct the growth in height of 10 years. This may be done by cutting off a portion of *ABE* representing the growth of 10 years. The exact length to be cut off cannot, of course, be hit upon at once. A portion estimated to be about the right length is sawn off; but supposing we find, by counting the number of its annual layers, that this piece represents the growth of only seven years, it will be necessary to cut off a portion representing the growth of three years more; another piece is, therefore, cut off, and so on, until the full 10 years' growth has been got rid of. The required diameter for estimating the contents of *abe* would be found by sawing through the remaining portion of the trunk at the point *o*, at a distance from its base equal to half its length. The diameter at *o* of *abe* will evidently be equal to the whole diameter, *op*, minus the breadth of 10 annual layers on either side of the disc.

If D is found to be 1 foot : $AE = 50$ ft. : $Ae = 44$ ft. : $d = 11$ inches : the increment for the 10 years will be

$$\cdot 7854 \times 1^2 \times 50 - \cdot 7854 \times \left(\frac{11}{12}\right) \times 44$$

$$= 39 \cdot 27 - 29 \cdot 04 = 10 \cdot 23 \text{ cubic feet.}$$

The yearly increment is, therefore, $\frac{10 \cdot 23}{10} = 1 \cdot 23$ cubic feet.*

* The contents of trees measured in this way may be most conveniently found by using the tables in the last chapter, in which the contents for any given diameter and height can be seen directly without calculation.

The rate of growth per cent. for the period is

$$\frac{10 \cdot 23}{29 \cdot 04} \times 100 = 35 \cdot 2.$$

And the rate per cent. for one year is $\frac{35 \cdot 2}{10} = 3 \cdot 52$.

The result obtained in this way may be used to estimate future increment, but not for long periods as the rate of growth of trees, more particularly when young, may diverge more and more from year to year.

Sometimes the past diameter-growth is measured, the future diameter deduced from the result, and the prospective contents of the tree calculated accordingly.

If we take, for instance, a tree of the same dimensions as in the last example, there will be an estimated diameter-growth of $12 - 11 =$ one inch, and a growth in height of $50 - 44 = 6$ feet, for the next period of ten years.

The future tree will, therefore, contain

$$\cdot 7854 \times \left(\frac{13}{12}\right)^2 \times (50 + 6) = 51 \cdot 62 \text{ feet,}$$

and the increment for the period will, therefore, be $51 \cdot 62 - 39 \cdot 27 = 12 \cdot 35$ cubic feet.

The rate per cent. for the period will be $\frac{12 \cdot 35 \times 100}{39 \cdot 27} = 31 \cdot 67$ and for one year $\frac{31 \cdot 67}{10} = 3 \cdot 17$.

Another method is to take the average yearly growth of the tree. If c represents the cubic contents of a tree of age a, its mean yearly growth will be $\frac{c}{a}$.

For a tree fifty years old and measuring 9 cubic foot, the mean yearly growth would be $\frac{9}{50} = \cdot 18$ cubic foot, and the growth per cent. $\frac{\cdot 18 \times 100}{9} = 2$.

The plan generally followed in estimating this kind of increment is to take the mean yearly growth of *exploitable* trees or groups; that is to say, if *r* is the length of the revolution, the mean yearly increment is found by dividing the contents of a tree or group *r* years old, by *r*.

Determination of the Increment by means of Increment-Tables.

By this method experiential tables are drawn up (as already described), showing the increment of groups from year to year. Or it will suffice, for all purposes, if the periodic increments from 5 to 5, or from 10 to 10, years, are shown, and the mean yearly growth during a period taken as the current (yearly) growth during such period. The class of a group being determined, if the area is fully stocked the yield per acre for any age will be seen directly in the table; but if portions of it are not fully stocked a proportionate allowance must be made.

Baur recommends* that the sum of the basal areas and the age and height of a group should be determined and compared with that of the tables. The average height and age will, he thinks (for reasons already given in the section on experiential tables, p. 117), suffice to indicate the class to which the group belongs. Then, if the sum of a group's basal areas per acre is equal to the sum of the basal areas of a tabular group of corresponding class and height, it will have the yields per acre for all ages shown in the

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* *Holzmesskunst*, p. 480.

tables; otherwise a proportionate reduction must be made.

Supposing, for instance, a group belongs to the first class, and that it ought to have, judging from its height, and according to the tables, a yield per acre of 7,523 cubic feet with a sum of basal areas of 150·46 square feet, but that we find it has a sum of basal areas of only 135 square feet. The contents of this group 50 years old would be found by the proportion 150·46 : 135 = 7,523 : x from which we find x = 6,750 cubic feet. This is 773 cubic feet, or 10·27 per cent. less than the quantity per acre shown in the table; therefore, if we wish to know what the increment of the group will be between its present age, 50, and, say, 60, we look up in the tables the yield of a group of the same class 60 years old, deduct 10·27 per cent. and take 6,750 cubic feet from the remainder. If the yield per acre in the table for a group 60 years old is 8,809 cubic feet, the calculation will be as follows:—

$8809 \times \cdot 8973 - 6750 = 7904 - 6750 = 1154$ cubic feet per acre, which is equivalent to an average annual increment of $\frac{1154}{10} = 115 \cdot 4$ cubic feet.

It would be necessary for this purpose that the experiential tables should show the sum of the basal areas for different ages. These may be calculated by the method of curves in the same way as other elements of the tables.

Determination of Increment by means of Tables on the Principle of the Bavarian Tables.

If tables of this kind are available, the increment during a period may be estimated in the following manner. The increment in height and diameter for a given number of years, say 10, is calculated for each diameter-class by means of sample-trees. The height, age, and diameter of each sample-tree 10 years hence at the same rate of growth, is then known, and its future contents at that time can, therefore, be read

directly in the tables.* In the same way, its present contents may be estimated, and the increment during the period determined by deducting one result from the other.

Choice of a Method.

For old groups the usual method is to take, as the actual current growth, the mean yearly growth for the whole revolution fixed, or (if r is its length, and m the cubic contents of the group) $\frac{m}{r}$. The mean yearly growth is tolerably stationary and about equal to the current growth at this period, but at earlier stages it is less, and the difference increases as we go back, so that for the youngest groups it is preferable to employ some other means, such as experiential tables. A great advantage of estimating increment by mean yearly growth is that it can generally be determined without special fellings, as the ordinary working of a forest will in nearly all cases furnish the necessary materials. If reliable experiential tables of the forest exist, the increment may be determined by them for groups of all ages.

In the case of young groups, except for general statistics of growth, it is not, as a rule, of much importance to know the increment.

Estimate of the Increment of Groups which are to be gradually cut down during a given period.

In this case, it will suffice to take half of what the increment of the group would be if it were not touched during the period, on the assumption that an equal portion of the stock is removed every year.

* These tables are described at p. 107.

CHAPTER XVII.

DETERMINATION OF THE YIELD OF THINNINGS AT DIFFERENT AGES OF GROUPS.

The yields of thinnings at different stages in the development of groups may be estimated from average results obtained in the forest under examination, or in other forests under similar conditions. Failing this, some data are sure to be obtainable. When the standing stock is examined, sample-groups will be found which require thinning, and the amount of such thinnings should be estimated and booked separately. This can be done best by cutting out the proper quantity of thinnings and estimating the amount before the predominant portion of the group is taken in hand. By this means very reliable data are certainly not obtainable unless information is forthcoming in regard to the former treatment of the group; but a beginning will, at all events, have been made towards a regular system of statistics, provided that the results obtained in each case are recorded with reference to the particular group in which the thinning was carried out, and that the strength of the thinning and conditions of growth of the groups are also noted. If groups are thinned at tolerably regular intervals during the revolution, it will then be possible sooner or later to draw up as reliable experiential tables of the yield of thinnings as circumstances allow.

The following tables constructed by Burckhardt* show the yields of thinnings from Scots' pine at different ages. They are based on the average results of extensive thinnings in different parts of the Province of Hanover. It is not stated if the forests in which the experiments were made had been previously thinned regularly, nor how they originated. The probability is that they had been severely thinned at irregular intervals of about ten years, after the 20th or 30th year, and that they had originated from the planting of seedlings at 4 feet distances.

YIELD PER ACRE OF SCOTS' PINE (THINNINGS).

Age.	Station.		
	Good.	Middling.	Poor.
	Cubic feet.	Cubic feet.	Cubic feet.
20–30	474	421	316
30–40	439	386	281
40–50	386	333	246
50–60	351	281	175
60–70	316	228	123
70–80	281	175	—
80–90	263	—	—
Total - - -	2,510	1,824	1,141
Mean Yearly Yield - -	28	23	16

* *Hülfstafeln*, p. 192.

CHAPTER XVIII.

COLLECTION OF ADDITIONAL STATISTICS AND FORMULATING RESULTS HITHERTO OBTAINED.

WHILST the forest is being explored in the manner described in the last, and in the above portion of the present, section, notes should be made regarding the future treatment of each group or compartment. Not that it is necessary to carry out the views expressed in the notes as to the future management of any particular group, as modifications may have to be made when the group comes to be treated as part of a series, but in order to get a basis on which to form a general plan of operations. Particulars to notice are, for instance, when a change of species, owing to bad growth of the standing stock, or to other reasons, appears advisable. The best mode of regenerating groups or restocking blanks and wastes will also have to be noted, and improvements which appear necessary in regard to roads, rides, young growth (stopping, thinning, &c.), drainage, and so forth.

Statistics of prices of all descriptions of principal and minor produce should also be collected, and inquiry made into the requirements of the population in the vicinity of the forest, its rights or privileges to take produce free, or on payment of royalties—a brief history, in fact, should be made out of the forest, including a statement of the tenure of the owner, of

the rights of others, and of its past treatment. A note should also be made of any lands of others, either inside, or outside, of the forest, which it would be desirable to acquire for forest purposes.

In a forest which is being organized for the first time it will not often be possible to give returns of the past yields of groups separately, but records of the yield of the whole forest in timber, firewood, (thinnings separately), and minor produce for several years back will often be available, together with the receipts and expenditure. It will then be possible to fix with more or less certainty the average gross and nett value of the standard unit of measure for each species and for each description of produce, superior and inferior.

Expenditure is either general or special. The former includes all outlay affecting the whole of the forest, such as surveys, rides, and roads; the latter those which affect only parts of the forest, such as cutting and cultivation-expenses.

The receipts and expenditure on account of different headings (cuttings, grazing, &c.) or sub-headings (log-wood, stacked wood, &c.) should be kept separate.

Other points to observe are:—The principal markets, roads, or other means of transport (railways, rivers). Large industrial undertakings demanding a constant supply of produce, such as paper and saw-mills, mining and smelting-works; price of labour, and whether it is abundant or difficult to procure when required; frequency or comparative absence of forest crime; the temporary and permanent staff employed in guarding the forest and in carrying out forest operations. Any other useful information likely

to affect the working of the forest should be noted, and in any case in which improvements seem possible suggestions should be made accordingly.

The general history and statistics are drawn up in a brief introductory report or statement.

The more important data should be scheduled in the following statements :—

1. Statement of Area.
2. Statement of Groups.
3. Statement of Age-Classes.
4. Statement of Boundary-Marks.

1.—Statement of Area.

This may be drawn up in the following form :—

Detailed Statement of Area of Rook's Nest Range, consisting of 12003·05 *acres, of which* 11200·55 *are forest-land and* 802·5 *roads, rides, ponds, and unculturable waste.*

Locality.	Compartments and Sub-Compartments.	Culturable Forest-land. Acres.	Unculturable Land.	Total.	Remarks.
Redhill - -	1*a*	10·05	-	-	
	b	21·30	-	-	
	c	17·02	-	-	
	d	31·57	-	-	
	e	—	1·02	79·96	Pond.
	2*a*	15·12	-	-	
	b	28·91	-	-	
	c	45·30	-	89·33	
	3*a*	49·32	-	-	
		etc.		etc.	

2.—Statement of Groups.

The following form may be used in this case, at least one page being given to each compartment. The unstocked area (taken up by rides, &c.) may be stated at the beginning or end. It will seldom be necessary to give the contents of young groups, or those which are not likely to be exploited during the first twenty years. This matter will depend in a great measure on the system of management adopted, as we shall see further on when examining the methods for determining the annual yield. When the entry can be dispensed with for young groups, it will sometimes be unnecessary to estimate their contents at all. It is not, however, easy to estimate the quality-class of a group unless its cubic contents are known, and if the contents have been estimated the figures should be entered here also.

DETAILED STATEMENT OF GROUPS IN ROOK'S NEST RANGE. ESTIMATED IN 1883.

COMPARTMENT No. 1.

Locality.	Sub-compartment.	Area acres.	Species.	Age.		Quality.		Leaf Cover.	Absolute Density.	Description of Soil and Situation.	Cubic contents feet.		Remarks and Suggestions for Future Management.
				Years.	Class.	Station.	Group.				Per acre.	Per sub-compartment.	
Redhill -	*a*	5·51	·4 sp. ·6 pine	45–55	III	·3	III s. I p.	·6	·6	Red sandstone; slope inclining to N.E. Shallow soil, sandy loam. Slight humus layer in parts, otherwise covered with growth of bilberries.	3,150	17,357	(*a*) Pine plantations in lines, with clumps of spruce. Situation unsuited to pine. Spruce better. Very open in parts, which have suffered from windfall.
	b	20·11	Spruce -	50	III	·8	IV	·9	·9		4,050	81,446	(*b*) Plantation in lines. Growth good, but irregular. Requires thinning in parts.
	c	10·57	Waste - -	...	...	·8	...	...	...		...	...	(*c*) Abandoned field. Plant up with spruce in lines, after taking root crop off the land.
	d	5·50	·5 sp. ·5 pine	90–100	V	·6	I p. II	·4	·4		2,420	13,630	(*d*) Very poor growth; should be cut away, and unmixed spruce planted. Has suffered much from insects.
	e	7·57	·5 sp. ·5 pine	15	I	·8	IV III p.	1·0	1·0		...	...	(*e*) Alternate rows of sp. and pine. Requires thinning.
Total - -	...	44·26											

3.—Statement of Age-Classes.

The object of this statement is to show at a glance the area occupied by each age-class of mixed and unmixed groups. There should be a separate statement for each species occurring unmixed and each mixed class of a forest; and each series of a range should have its separate tables. The quality-class of the groups should also be stated.

Statement Showing the Age-Classes of the First Series (Scots' Pine) of Rook's Nest Range in 1883.

compartment.	Quality Class of the Group.	Class I. 1—20 years. Acres.	Class II. 21—40 years. Acres.	Class III. 41—50 years. Acres.	Class IV. 51—60 years. Acres.	Class V. 61—70 years. Acres.	Class VI. 71—80 years. Acres.	Class VII. 81—90 years. Acres.	Blanks.	Wastes.
a	IV.	...	...	...	...	...	5·75			
b	IV.	...	...	...	10·41					
c	III.	...	...	...	...	25·10				
d	IV.	...	...	...	15·73					
c	I.	10·45	...							
d	I.	5·13	...							
g	III.	...	13·5							
otal ...		15·58	13·5	...	26·14	25·10	5·75			

4.—Statement of Boundary-Marks.

Besides being shown on the map, it is well to have a register of boundary-marks, so that, in the event of any disappearing, the exact position in which they should be may be easily found. The following tabular statement will suffice for this :—

STATEMENT OF BOUNDARY-MARKS IN ROOK'S NEST RANGE IN 1883.

Adjacent compartment.	Number of Mark.	Description of Mark.	Distance to boundary mark on the right, facing inwards. Yards.	Angle included by lines joining centre station with boundary marks on right and left, facing inwards.	Remarks.
1	1	Stone	150·45	75° 31′	Meets the stream.
1	2	do.	200·30	105° 10′	On edge of meadow.
			&c.		

It will often be possible to schedule other important matters, such as the past annual yields and average prices of different kinds of produce, which are more easily examined in a concise form.

SECTION IV.—DETERMINATION OF YIELD.

CHAPTER XIX.—SERIES.

As we have already seen, a range must sometimes be divided into more than one series.

In selecting groups which are to belong to the same series, it is, in the first place, essential that they should be capable of being subjected to the same, or nearly the same, treatment. It would not do, for instance, except as a temporary arrangement, to have groups of different revolutions in the same series—an oak coppice, for example, in the same series as spruce. On the other hand, beech, spruce, and silver-fir groups might be ranged together under one series, as the same treatment and revolution might answer for all three.

It is also desirable that groups of the same series should not be of very different qualities, because the most favourable revolution for a species growing in a very good station may be very different from that of the same species growing in a bad station; and because the yield, as we shall see further on, is rendered more fluctuating if the stations vary in quality than if they are tolerably uniform.

It is further desirable that the groups composing a series shall not be very far apart, nor straggling in

small patches here and there, but consist of fairly-sized compact masses, not necessarily contiguous, but belonging, naturally and topographically, to the same tract of country.

The first step, then, to be taken, is to decide the *régime* and revolution best suited to each group or species occurring in the range. Those to which the same treatment can be applied are then scheduled according to age-classes and the areas they occupy. With the assistance of a map and notes, a good general view of the situation is thus obtained, and the organiser is in the best position to decide how many series to have and what groups to select for each.

It will often happen in the preliminary investigation that several groups have been united which do not take up an area sufficiently large to constitute a complete series having due regard to the annual coupes being of a proper size. In that case they will have to be divided amongst other series, or treated separately as incomplete series with periodical yields. Sometimes a group may be found—as, for example, when a protective group, treated by the primitive method, occurs in the midst of forest managed on a regular system—which cannot be made to fit into any series. In that case the group will have to be worked separately, and not as belonging to any series.

Groups belonging to one series should always be separated from those of other series by natural or artificial boundaries, such as rivers, roads, and rides, in order that there may be no difficulty in the location of the cuttings of either series.

CHAPTER XX.

METHODS OF DETERMINING THE ANNUAL YIELD OF FORESTS COMPOSED OF TOLERABLY REGULAR GROUPS.*

THE principal methods may be summed up as follows :—

1. Method of Compartments.
2. Hartig's Method.
3. The Combined Method.
4. The Austrian Method.
5. The Financial Method.

METHOD OF COMPARTMENTS.

The honour of having made the first step towards a determination of the sustained yield of a forest is claimed by M. Parade for the French, and by Oberforstrath Judeich for the Germans.† According to the latter, the method of dividing the forest into as many equal compartments as there are years in the revolution had been in vogue in Germany long before the year 1585.

Be that as it may, we know for certain that about the middle of the sixteenth century the plan of di-

* "Tolerably regular groups" must here be understood as including all groups whose trees are sufficiently regular to admit of their being exploited at the same time. A very considerable degree of irregularity is, therefore, admissible.

† Short histories of the development of the systematic determination of the yield from the French and German points of view will be found in M. Nanquette's "*Cours d'aménagement des forêts*" and Oberforstrath Judeich's *Forsteinrichtung*.

viding forests into as many coupes as there are years in the revolution began to be generally recognised as a more rational system than the old plan of cutting out trees here, there, and everywhere, which rendered it impossible to determine the sustained yield, regulate cuttings, or ensure the regeneration of the forest.

The earliest form of this method consisted in marking off annual cuttings of the required size, and exploiting them one after another in each block, so as to obtain a good sequence of cuttings. It soon, however, became apparent that, for seedling-forests with their long revolutions, it was quite unsuitable, and that, subject as they are to all sorts of disturbing influences, such as damage by snow, wind, and insects, it was impossible to fix what groups should be cut fifty or a hundred years hence. Another objection to it was that it necessitated great sacrifices, because young growth, as will be seen presently, had often to be cut long before it was exploitable, and old stock kept long standing uncut. At the present time, therefore, it has been generally abandoned in favour of more elastic methods; but it still remains, under a modified form, on account of its simplicity, one of the best methods of exploitation applicable to coppice-forests, to which the above objections do not apply, or, at all events, apply only in a very limited degree. The annual yield, too, being in their case, area for area, so much smaller than in seedling-forests, differences of station affect the quantity of the cuttings in a much less degree than in forests with long revolutions, in which the annual yields, determined by the system of equal areas, may vary very greatly, thereby causing serious fluctuations of revenue.

By this method, if A is the area of the forest, c that of the annual coupe, r the revolution, we shall have

$$c = \frac{A}{r}$$

or, if there is to be a fallow of n years,

$$c = \frac{A}{r + n}$$

Sometimes the method of proportional coupes is adopted: that is, the area of the coupe is made inversely proportional to its relative yield.

Supposing, for example, that we have a series stocked with oak coppice, and consisting of the following compartments, and that the revolution is 30 years.

Compartment 1, of 50 acres, capable, it is estimated, of yielding in the thirtieth year 2,550 cubic feet per acre.

Compartment 2, of 65 acres, capable of yielding 2,040 cubic feet in the thirtieth year.

Compartment 3, of 45 acres, capable of yielding 1,730 cubic feet in the thirtieth year.

We would then have a total production during a revolution of

From No. 1	50 × 2550 =	127500 feet.
From No. 2	65 × 2040 =	132600 „
From No. 3	45 × 1730 =	77850 „
	Total..............	337950

The mean yearly production would, therefore, be for a complete series

$$\frac{337950}{30} = 11265 \text{ cubic feet,}$$

and the size of a coupe would be in

Compartment 1 .... $\frac{11265}{2550} = 4{\cdot}41$ acres.

„ 2 .... $\frac{11265}{2040} = 5{\cdot}52$ „

„ 3 .... $\frac{11265}{1730} = 6{\cdot}51$ „

Another method is to make the area of the coupe inversely proportional to the estimated relative quality of the station.

In the above example, for instance, if the quality of the best station, say No. 2, is taken as a standard of comparison, and represented by unity, of No. 1 by ·9, and of No. 3 by ·7, we should have

65 acres giving each the full yield of	65	standard acres.
50 „ giving ·9 of the full yield, or the equivalent of only ...	45	„
45 acres giving ·7 of the full yield, or the equivalent of only ...	31·5	„
Total equivalent to	141·5	„

For a revolution of thirty years the coupe must, therefore, be equal to a standard coupe of

$$\frac{141{\cdot}5}{30} = 4{\cdot}72 \text{ acres},$$

and in No. 1 compartment the size of the coupe would be $\frac{4{\cdot}72}{{\cdot}9} = 5{\cdot}24$ acres,

in No 2 compartment $\frac{4{\cdot}72}{1{\cdot}0} = 4{\cdot}72$ „

and in No. 3 compartment $\frac{4{\cdot}72}{{\cdot}7} = 6{\cdot}74$ „

Supposing the data of the estimate to be correct, the former method would give a uniform yield during the revolution, but would not bring about the ideal state at the end. This object would be attained by the latter method at the price of more or less irregular yields during the revolution.

Of the two factors, station or standing stock, the latter is less difficult to estimate, and as it is generally a matter of importance to get uniform yields, the former plan is perhaps the better of the two. The plan, however, which is usually adopted, and which answers for all practical purposes in coppice-forest, is to consider the yearly coupe equal to $\frac{A}{r}$; the cuttings in that case can be equalised, if necessary, by taking a little more here or a little less there, when it is found that the yield is above or below the average.

Cotta's Modification.

By this method the compartments of a forest were assigned to *affectations*, each one of which comprised the same number of coupes. Hence, the number of the latter, or, what amounted to the same thing, the number of compartments, in an affectation corresponded to the number of years required to work through an affectation, and this term of years was, therefore, called a *period*. A period in forests subject to a revolution of 60 years or more was to consist of 20 to 30 years, but for those with shorter revolutions of 10. The whole forest area was divided into equal affectations, unless differences of station were very great, when a little more might be given to one and a

little less to another; but, as a general rule, Cotta considered that it was much more important to endeavour to attain uniform coupes than uniform yields.

If the area of a forest were, for example, 300 acres, its revolution 120, and a period 30 years, the annual coupe would be $\frac{300}{120} = 2\frac{1}{2}$ acres, and an affectation $30 \times 2\frac{1}{2} = 75$ acres. If normal, the first affectation would consist of thirty compartments stocked with a series of groups from one to thirty years old; the second affectation would consist of a similar series 31 to 60, the third of a series 61 to 90, and the fourth of a series 91 to 120 years old. Each compartment was permanently allotted to a certain affectation, and the greatest stress was laid on the importance of having a regular sequence of cuttings.

Cotta's method was an improvement on the previous method to the extent that it afforded a certain amount of freedom in the allotment of compartments to affectations. Its superiority was, however, more apparent than real, because it still insisted on the cuttings in each block following in regular order one behind the other. For forests in which the age-classes are in perfect harmony with such a system there may be little objection to its adoption; but it is a very different matter when the method comes to be applied to forests in which the age-classes are scattered over the forest without order, old groups occurring perhaps in every affectation. The result is, then, that groups with little or no increment in value have to be left standing whilst vigorous young groups are being sacrificed in order that a regular sequence of coupes and arrangement of age-classes may be attained. When, therefore, this method came to be applied it

was found that, although a good sequence of age-classes might be ultimately attained, there was scarcely less difficulty than before in allotting compartments advantageously; that when a few had been marked off the remainder had to follow in a certain sequence, in order that danger to the standing stock might not ensue. If, for instance, cuttings were carried on at the same time in two or more adjoining compartments, there might be danger of their causing together too great an opening in the forest, and thereby exposing the surrounding standing stock to danger from wind, besides giving rise to other risks consequent on having coupes which were too large.

Supposing, for example, that the accompanying

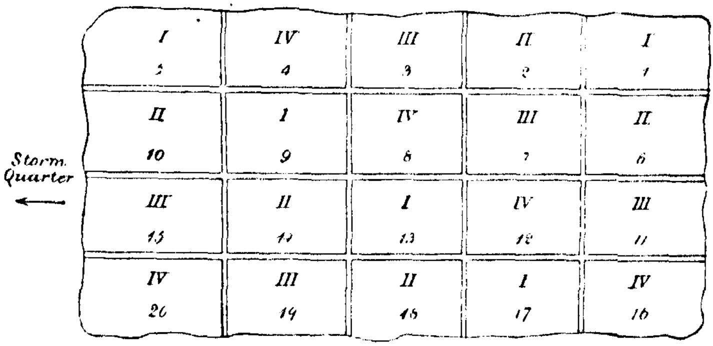


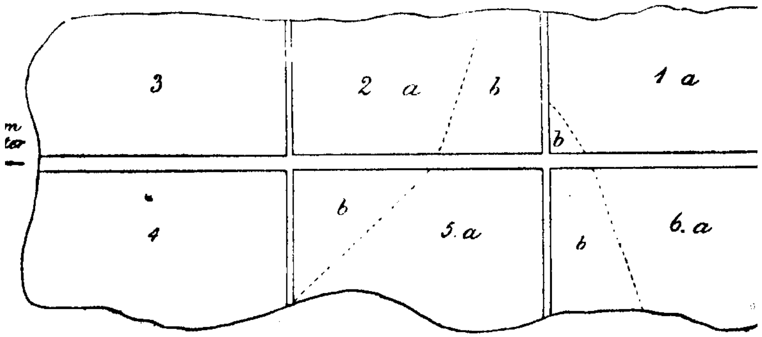
figure represents a pine-forest in the plains, that the stormy quarter is to the west, and that the cuttings run from east to west. The compartments 1, 2, 3, &c., may be apportioned on Cotta's plan to the affectations I., II., III., and IV. (if there are four periods in the revolution) in the manner shown in the diagram. It would not do with this arrangement of the other compartments to put No. 6 into the first or

third affectation, as that would necessitate a double breadth of coupe; nor would it do to put any two or more contiguous compartments of a block, *e.g.*, 1, 2, 3, 4, or 5, into the same affectation. As soon, therefore, as a certain number of compartments has been assigned to affectations the others must follow in an order which is more or less independent of all requirements other than those of a good sequence.

There is, however, no absolute necessity of rigidly following this plan, and, in the following example of the method of compartments, we will therefore adopt the modern system of cutting the oldest groups first, whenever possible, by which means losses are reduced to a minimum.

Example of the Determination of the Annual Yield by the Method of Compartments.

The accompanying sketch-map represents the plan



of a small beech and oak seedling-forest of ninety acres, which is to be converted into oak coppice with a revolution of thirty years.

The area is divided into six compartments, of fifteen acres each, containing the following groups :—

1*a*,	14 acres,	group	25	years old.
1*b*,	1	,,	5	,,
2*a*,	10	,,	15	,,
2*b*,	5	,,	5	,,
3 ,	15	,,	35	,,
4 ,	15	,,	35	,,
5*a*,	10	,,	27	,,
b,	5	,,	15	,,
6*a*,	9	,,	5	,,
b,	6	,,	31	,,

It is found from records that the average production of the forest per acre has been the following during the last fifteen years :—

YIELD PER ACRE.

Age of group.	Cubic contents, feet.	Average yearly growth, feet.
15	725	48
20	1,300	65
25	1,750	70
30	2,100	70
35	2,380	68
40	2,600	65
45	2,880	64

The annual coupes will amount to $\frac{90}{30} = 3$ acres. There will be three periods of ten years each, and three affectations of $3 \times 10 = 30$ acres each.

The stormy quarter being on the left, the cuttings should progress from right to left.

The compartments best suited for the first affectation, having regard to the age of the groups they contain, are numbers 3 and 4, of 15 acres each, with groups 35 years old. As the adjacent groups in 2*a* and 5*b* are only 15 years old, there appears to be no objection to exposing these by cutting away the older groups in front of them. We should then have the following yield and coupes for the first affectation:—

Compartment.	Present age of group.	Average age of group at time of cutting.	Area of compartment or sub-compartment.	Yield per acre, cubic feet.	Total yield of group.	Yield of affectation, 1883—1892.	Mean yearly yield.
4	35	40	15	2,600	39,000	78,000	7,800
3	35	40	15	2,600	39,000		

At the end of the first period the oldest groups remaining will be

6*b*, of 6 acres,	with group	41	years old.
5*a*, of 10 ,,	,,	37	,,
1*a*, of 14 ,,	,,	35	,,

The groups in 6*a*, behind 6*b*, being only fifteen years old, there is no objection to the older group being cut. 1*a* may evidently be cut, and after the removal of 6*b*, 5*a* may also be cut. For the second

affectation we would then have the following yield and coupes :—

Compartment.	Age of group at beginning of the period.	Average age of group at time of cutting.	Area of coupes.	Yield per acre.	Total Yield.	Yield of affectation, 1893–1902.	Average annual yield per annum.
			Acres.	Feet.		Cubic ft.	Feet.
6b	41	46	6	2,944	17,664	...	...
5a	37	42	10	2,730	27,300	81,364	8,136
1a	35	40	14	2,600	36,400	...	...

For the third period we would have remaining

2b, of	5	acres,	with group	25	years old.
2a, of	10	,,	,,	35	,,
5b, of	5	,,	,,	35	,,
6a, of	9	,,	,,	25	,,
1b, of	1	,,	,,	25	,,

These might be worked in the order named, without any danger to standing stock. The yield would then be

Compartment.	Age of group at beginning of period.	Average age of group at time of cutting.	Area of coupes.	Yield per acre.	Total Yield.	Yield of affectation 1903–1912.	Average yield per annum.
			Acres.	Feet.			Feet.
2b	25	30	5	2,100	10,500	...	...
2a	35	40	10	2,600	26,000	...	...
5b	35	40	5	2,600	13,000	70,500	7,050
6a	25	30	9	2,100	18,900	...	...
1b	25	30	1	2,100	2,100	...	...

At the end of the revolution the oldest group would be thirty years of age, and the average age of the groups in the first affectation would be twenty-five years. During the next revolution, therefore, the sub-compartments might be got rid of, if desired, without much loss; ten acres stocked with groups averaging twenty years of age instead of thirty would have to be entered in the first period; on the other hand, two-thirds of the groups in five, occupying ten acres, would have to be cut at an average age of forty years. Supposing the relative production to be the same as before, the yield for the second revolution would then be :—

Affectation and Period.	Compartment.	Age at beginning of period.	Average age of groups at time of cutting.	Area of compartment or sub-compartment.	Yield per acre, feet.	Total yield of group.	Yield of affectation.	Mean yearly yield.
I.	3	25	30	15	2,100	31,500	63,000	6,300
	4	25	30	15	2,100	31,500		
II.	1*a*	25	30	14	2,100	29,400	55,000	5,500
	b	15	20	1	1,300	1,300		
	6*a*	15	20	9	1,300	11,700		
	b	25	30	6	2,100	12,600		
III.	5*a*	35	40	10	2,600	26,000	68,000	6,800
	b	25	30	5	2,100	10,500		
	2*b*	25	30	5	2,100	10,500		
	a	25	30	10	2,100	21,000		

The yield after the second revolution would then be uniform for each affectation, namely, 63,000 cubic feet, yielding an annual income of 6,300 cubic feet.

If it was thought desirable to equalise the estimated yields of the II. and III. periods during the first revolution, that might be accomplished by taking $2\frac{1}{2}$ acres of *5a* into the first affectation, the yield for the second period would then be 62,000 cubic feet, with an annual cutting of 6,200 ; and the cuttings during the third period would amount to 61,000 feet, equal to an annual yield of 6,100 feet. This would, however, be a departure in the direction of the combined method, and inadmissible by this one.

The coupes are shown in affectations in the above example, but it is not necessary to have these for the coppice-*régime*. Both affectations and periods can well be dispensed with when the area is the sole regulator of the annual cutting. The coppice-*régime* was chosen because it is, as we have already seen, the only one at all suited to the method of compartments.

Hartig's Method.

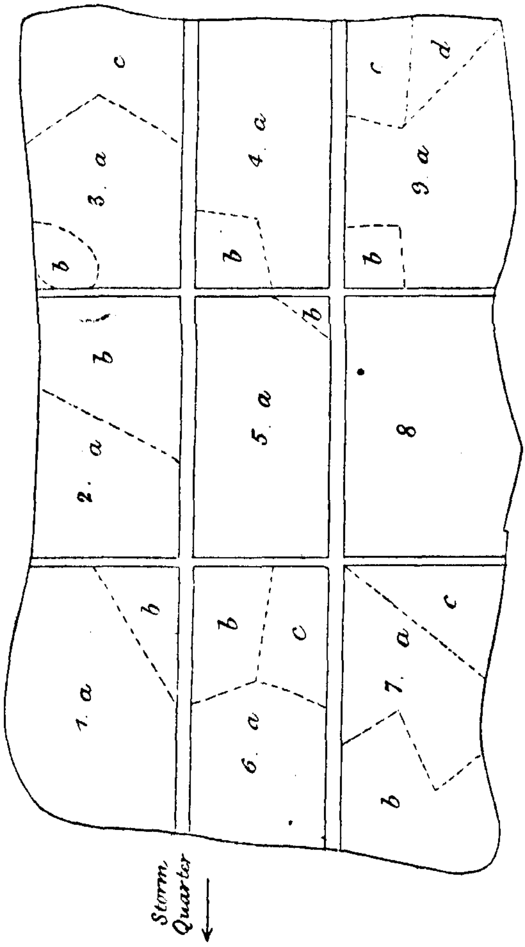
In the year 1795 G. L. Hartig published a method* of estimating the yield, based on the quantity of standing stock in the forest, without reference to its area.

His method consisted in estimating the contents and increment of the whole forest, dividing the revolution into periods, and so arranging the cuttings that the same quantity of estimated material should be cut in each period.

The accompanying diagram represents the plan of a seedling-forest, on tolerably level ground, and of uniform productivity. It is divided, as seen in the plan, into nine compartments of nearly equal area, aggregating 442 acres. The species, constituting unmixed groups of pine and mixed groups of silver fir and beech, are, we will suppose, capable of

* *Anweisung zur Taxation der Forste.*

yielding the returns per acre, at different ages, shown in the tables given below. The compartments are all fully stocked. The revolution most suitable to the object of the proprietor is 60 years for the pine groups and 120 for the mixed groups.



STATEMENT OF GROUPS.

1.—*Beech and Silver Fir.*

1*a*,	40	acres	with group	65	years old.
2*a*,	25	,,	,,	30	,,
b,	25	,,	,,	60	,,
3*a*,	25	,,	,,	90	,,
3*b*,	5	,,	blank	pond	,,
4*b*,	8	,,	with group	15	,,
5*a*,	47	,,	,,	110	,,
6*a*,	28	,,	,,	80	,,
c,	12	,,	,,	40	,,
9*d*,	7	,,	,,	90	,,
	222				

2.—*Pine.*

1*b*,	10	acres,	with group	15	years old.
2*b*,	5	,,	,,	80	,,
c,	20	,,	,,	5	,,
4*a*,	32	,,	,,	30	,,
5*b*,	3	,,	,,	90	,,
6*b*,	10	,,	,,	15	,,
7*a*,	18	,,	,,	5	,,
7*b*,	17	,,	,,	60	,,
c,	12	,,	,,	5	,,
8 ,	50	,,	,,	70	,,
9*a*,	30	,,	,,	40	,,
b,	5	,,	,,	blank	,,
c,	8	,,	,,	50	,,
	220				

STATEMENTS OF YIELDS PER ACRE.

Silver Fir and Beech.			Pine.		
Age of group.	Cubic contents. Feet.	Mean yearly growth. $\frac{b}{a}$	Age of group.	Cubic contents. Feet.	Mean yearly growth. Feet.
a	*b*	*c*			
20	680	34	20	1,400	70
30	1,430	48	30	2,300	77
40	2,380	60	40	3,300	83
50	3,400	68	50	4,400	88
60	4,590	77	60	5,400	90
70	5,610	80	70	6,300	90
80	6,460	81	80	7,000	88
90	7,310	81	90	7,500	83
100	7,990	80	100	7,900	79
110	8,670	79	110	8,200	75
120	9,180	77	120	8,400	70
130	9,520	73			
140	9,860	70			
150	10,050	67			

Two series will suffice, one for the silver fir and beech with a revolution of 120 years, and the other for the pines with a revolution of 60 years.

To begin with the former series, the first step to take is to find out the present quantity of the standing stock. Taking the oldest groups first, there will be

Sub-compartment.	Area acres.	Age of group.	Cubic contents per acre. Feet.	Total contents of group.	Mean yearly growth. $\frac{e}{c}$
a	*b*	*c*	*d*	*e*	*f*
5*a*	47	110	8,670	407,490	3,704
9*d*	7	90	7,310	51,170	569
6*a*	28	80	6,460	180,880	2,261
1*a*	40	65	5,100	204,000	3,138
2*b*	25	60	4,590	114,750	1,913
6*c*	12	40	2,380	28,560	714
2*a*	25	30	1,430	35,750	1,192
3*a*	25	20	680	17,000	850
4*b*	8	15	510	4,080	272
Total ...	217	...	...	1,043,680	14,613

The contents of the groups 3*a* and 4*b* are found approximately by deducting five years' mean growth from the yield shown in the tables for a group twenty years old.

The total contents of the forest being about 1,044,000 cubic feet, and the revolution 120 years, we should be able to cut annually about $\frac{1044000}{120} = 8{,}700$ cubic feet, plus the increment on the stock during each successive year. This increment, if the forest is to be exploited regularly, would, we may assume, decrease in an arithmetical ratio, and the quantity available during the revolution would, therefore, be $(0 + 14{,}613)\frac{120}{2} = 876{,}780$ cubic feet, giving an average annual yield of $\frac{876780}{120} = 7{,}307$ cubic feet. Under these circumstances, the annual yield of the forest during the first revolution would be $8{,}700 + 7{,}307 = 16{,}007$ cubic feet. The yield for a period would be twenty times this amount, or 320,140 cubic feet.

We might, therefore, start to determine the annual yield at the above rate of consumption. If, as is highly probable, it turned out wrong, we should have to try again and again, until, by a lucky chance, we hit upon something like the following arrangement, which gives a practically uniform yield for each period.

Affectation and period.	Sub-compartment.	Area.	Age of group at beginning of period.	Average age at time of cutting.	Cubic contents per acre. Feet.	Total cubic contents yielded. Feet.	Contents of affectation.	Averag annua yield.
I.	5*a*	34	110	120	9,180	312,120	312,120	15,60
II.	5*a*	13	130	140	9,860	128,180	311,780	15,58
	9*d*	7	110	120	9,180	64,260		
	6*c*	12	60	70	5,610	67,320		
	6*a*	6	100	110	8,670	52,020		
III.	6*a*	22	120	130	9,520	209,440	313,480	15,67
	2*b*	12	100	110	8,670	104,040		
IV.	2*b*	13	120	130	9,520	123,760	311,525	15,57
	2*a*	23½	90	100	7,990	187,765		
V.	2*a*	1½	110	120	9,180	13,770	311,270	15,56
	1*a*	31¼	120	130	9,520	297,500		
VI.	1*a*	9¾	140	150	10,050	97,988	312,800	15,64
	3*a*	25	120	130	9,520	238,000		
	4*b*	8	115	125	9,350	74,800		

In explanation of the above arrangement, the following remarks may appear necessary:—

There is evidently no objection to exploiting thirty-four acres of 5*a* during the first period.

In the second period, there will be no objection to cutting the remainder of 5*a* and also 9*d*; but the next on the list, 6*a*, cannot be cut until 6*c* has been removed, as it would never do to suddenly expose this group at the age of sixty to the full force of

the storm. We must, therefore, sacrifice it, or pass on to another block. On the whole, it appears better to continue the sequence, as there would be difficulty later on in getting out the group in 6*c* on account of the younger group in 5*a*; and it is, moreover, imperatively necessary to exploit 6*a* soon, as that group has already reached the age of 100 to 120 years. Accordingly, we put down 6*c* and part of 6*a* in the second affectation, proceeding first of all to clear away a safety-path in 6*a* thirty feet broad on the border of 5*b*, so as to prepare the young pines in 6*b* for exposure when the group in front of them is cut.

For the third period, the remainder of 6*a* may be entered, although it is, generally speaking, not at all desirable to have so many cuttings following each other every year one behind the other; * it might, therefore, have been preferable to postpone cuttings in 6*a* (with the exception of the protective clearing) until the third period. How a point of this kind is decided depends on circumstances, such as the lie of the ground, whether hilly or flat, the demands of different markets, mode of regeneration, climate as affecting regeneration and in regard to storms, occurrence or absence of dangerous insects, &c. We will suppose that it is decided to leave things as at first arranged. We shall then have the remainder of 6*a* in the third affectation, and may make up the rest from 2*b*. 1*a* is the next on the list, but it protects the pines fifty-five years old (unless they have been

* I am aware that opinions in regard to this matter differ considerably; the opposite view is generally adopted in France. There are advantages and disadvantages in either case, and no hard-and-fast rule can be laid down.

cut) in 1*b*, and is also immediately in front of the beeches seventy years old in 2*a*, which is only separated from it by a narrow minor ride. It is, therefore, better to take 2*b* first, more particularly as it will be fully 110 years old before being cut.

In the fourth period we may enter the remainder of 2*b* and part of 2*a*.

In the fifth period the remaining portion of 1*a* will be cut, and, provided that the arrangement of the cuttings in the pine series will admit of it, 3*a* and 4*b*. These two are, therefore, entered provisionally.

We should thus have a plan of cuttings in which the periodical returns are pretty evenly balanced, and which could be carried out without much loss to the proprietor, the only very immature group which is to be cut being 6*c*; all the others are of about the proper age. But, supposing that it had been necessary to sacrifice a number of immature groups, the prospect would have been a very different one, and serious inconvenience have resulted if it was intended to regenerate the forest in the natural way by seed, not to mention the loss of revenue. Hartig relied on making up for irregularities in the age of groups by means of thinnings, retarding the cutting of immature groups by increased thinnings, and pushing on the exploitation of over-mature groups by reducing thinnings. But there are many forests in which thinnings are mostly removed by right-holders, and are, therefore, not available for this purpose; and others, again, in which the thinnings, except of the oldest groups, have no value, and cannot, therefore, be considered. As regards forests generally, it must be remembered that thinnings are the result of

sylvicultural measures which cannot well be postponed, or anticipated, without damage to the standing stock; but, apart from these considerations, it appears extremely improbable that deficiencies could always be made good in this way.

Turning now to the pine-series, we find that the following are the particulars of the groups of this series:—

Sub-compartment.	Area, acres.	Age of group.	Cubic contents per acre.	Total cubic contents of group.	Mean yearly growth.
5*b*	3	90	7,500	22,500	250
2*b*	5	80	7,000	35,000	438
8	50	70	6,300	315,000	4,500
7*b*	17	60	5,400	91,800	1,530
9*c*	8	50	4,400	35,200	704
9*a*	30	40	3,300	99,000	2,475
4*a*	32	30	2,300	73,600	2,453
1*b*	10	15	1,050	10,500	700
6*b*	10	15	1,050	10,500	700
7*a*	18	5	—	—	—
3*c*	20	5	—	—	—
7*c*	12	5	—	—	—
9*b*	5	0	—	—	—
—	220	—	—	693,100	13,750

If we add together, as before, the average yield of 693,100 cubic feet for sixty years, or $\frac{693100}{60} = 11,552$ cubic feet and half the present increment, namely, 6,875 feet, we get an annual yield of 18,427 feet; or 368,540 cubic feet for each of the three periods of twenty years. Accordingly, not having a better guide, we proceed to try if about 368,000 feet for each period will give a tolerably uniform yield, but

find that it is much less than the capability, and are obliged to try again and again, until we hit upon the right quantity. It is useless to go through all these failures in detail; we will, therefore, begin at once with a periodical yield of about 450,000 feet, which will be found to be about the right quantity.

Affectation and period.	Sub-compartment.	Area.	Age of group at beginning of period.	Average age of group at time of cutting.	Cubic contents per acre.	Total cubic contents yielded.	Contents of affectation.	Avera annua yield
I.	5*b*	3	90	100	7,900	23,700	449,000	22,45
	2*b*	5	80	90	7,500	37,500		
	8	50	70	80	7,000	350,000		
	7*b*	6	60	70	6,300	37,800		
II.	7*b*	11	80	90	7,500	82,500	449,000	22,45
	9*c*	8	70	80	7,000	56,000		
	9*a*	30	60	70	6,300	189,000		
	4*a*	22½	50	60	5,400	121,500		
II.	4*a*	9½	70	80	7,000	66,500	450,500	22,52
	1*b*	10	55	65	5,850	58,500		
	6*b*	10	55	65	5,850	58,500		
	7*a*	18	45	55	4,900	88,200		
	3*c*	20	45	55	4,900	98,000		
	7*c*	12	45	55	4,900	58,800		
	9*b*	5	40	50	4,400	22,000		

We assume that the blank is filled up during the first year with pines. Whether it would be advisable or not to change the species of some sub-compartments sooner or later, if possible, 6*b*, for example, is a question which we need not consider, our object being, not to set up a general plan of operations, but simply to calculate the yield of the forest as we find it.

5*b*, 2*b*, and 7*b* may evidently be cut during the first

period, 8 may also be cut. That will expose the pines in 9*a*, forty years old at the commencement of the period. If these are much drawn up, and the station exposed to dangerous winds, it would perhaps be a little late to begin cuttings in 8. They are, however, separated from the latter compartment by a minor ride, so that the trees on its border will have had room to expand: and, if it is thought necessary, only a strip twenty feet broad may be cut in the group 5*a* along the minor ride, and further cuttings postponed until the border-trees in 4*a* are considered sufficiently strong to admit of their being continued with safety. We may then safely enter 8 in the first affectation.

In the second period the remainder of 7*b* and 9*c* and 4*a* may all be cut, also 9*a*, because the beeches and firs in 9*d* are to be felled during this period.

For the third period we may take the remainder of 4*a*. As regards 1*b*, the next on the list, it will be observed that it protects the group in 2*a*, which was sixty-five years old at the beginning of the period, and is too old to be exposed, the narrow minor ride not being sufficiently broad to enable the group to do away with all protection in front. Nevertheless, it is highly desirable that it should be cut down in this period, otherwise it must be left standing fifty years longer, until the group in 2*a* is cleared off. A protective clearing twenty feet broad should, therefore, be made in 1*b* along the edge of the minor ride during the first period, to enable the trees on the other side to strengthen their roots and lower branches, and thus form a protective fringe by the time the pines in front are removed.

The old group in compartment 5*a* having been removed during the second period, the young growth now there will not exceed twenty years of age at the beginning of this period. We may, therefore, enter also 6*b*. The groups 7*c*, 7*a*, 9*b* may also be cut without danger.

The above arrangement of cuttings fits in well with that for the beech and silver fir series; they may, therefore, both be allowed to stand.

A serious objection to employing this method, even in forests in which the age-classes are for the moment tolerably complete, is the utter impossibility of determining accurately the yield of a group for many years in advance. The whole estimate, even supposing that no causes arise to mar the plan, rests on far too speculative and uncertain data as regards seedling-forest with long revolutions, whilst for coppice the method of compartments is greatly to be preferred.

The sacrifice of revenue, consequent on not cutting groups at the exact time of their exploitability, is just as great by Hartig's method as by the method of compartments, but the latter has at least the merit of bringing about, as nearly as is possible, the ideal state at the end of the first revolution, an object which cannot be attained by Hartig's method, unless the age-classes are complete at starting.

The Combined Method.

This method is the outcome of the two former. The areas of the affectations are not necessarily the same, but are made to depend mainly on the relative proportion of the age-classes of a series, in order that

very immature groups may not have to be cut. The areas of the affectations being fixed, the yield for each is determined by Hartig's method, so as to obtain a uniform yield during each period, or the affectation and yield of the first period, or first and second periods, alone are fixed. Very excessive, or very insufficient cuttings are guarded against by the affectations being fixed by area, and although a uniform yield is seldom at once attained for the whole series, it is obtained for each period, and the ideal state is sooner or later effected at the least possible loss to the proprietor.

The determination of the yield of more than two periods is now seldom attempted. It can certainly do no harm to estimate the possible yield for any number of periods, but experience teaches that such calculations are sure to be upset, and that it is quite impossible, even under the most favourable circumstances, to determine satisfactorily the future yield of a group for more than a comparatively short space of time. Nor are there under the circumstances any very great advantages to be derived from such an estimate, supposing that it be approximately correct. A certain area, whose size depends on the relative proportion of the age-classes in a series, is fixed for one or more affectations, and a very accurate estimate of the future yield of young groups will not materially affect this arrangement. On the other hand, a great saving of time and trouble will be achieved, once it has been decided to give up the attempt, as it will then suffice to determine the contents of young groups by the simplest means instead of by the most accurate and costly.

The combined method will be best explained by an example. We will take for this purpose the pine series of the last example (page 187).

The area of the series is 220 acres, the revolution 60 years, and the normal coupe would, therefore, be $\frac{220}{60} = 3{\cdot}67$ acres.

We should then have the following normal and actual areas occupied by each age-class, if the age-classes proceed by differences of 20 years. Each age-class will correspond to a period.

Age-class.	Area occupied by each Age-class.			
	Normal.	Actual.	Too much.	Too little.
I. 1—20 years old	73·33	75·00	1·67	—
II. 21—40	73·33	62·00	...	11·33
III. 41—60 and over	73·34	83·00	9·66	—

In the first age-class, a blank of 5 acres is included in the above. This class is very fairly represented.

As regards the other two, the surplus quantity of the older class will more than compensate for the deficit in the second class, and we might safely put the full area of 73·33 acres into the first period, or even more, considering how much over-mature timber there is. To be on the safe side, there being a marked deficiency in the second class, and to better equalise the yield, we will put down only 72 acres.

We shall then have the following estimated yield for the first period :—

Compartment.	Area. Acres	Age at beginning of period.	Average age at time of cutting.	Yield per acre. Feet.	Total yield. Feet.	Yield of the affectation.	Average yearly yield.	Remarks
b	1	15	25	1,850	1,850			1*b*. Protective cutting
b	3	90	100	7,900	23,700			
b	5	80	90	7,500	37,500	494,950	24,748	
	50	70	80	7,000	350,000			
b	13	60	70	6,300	81,900			

The allotment of groups to the next two periods should be ascertained roughly, so as to enable the organizer to adopt measures, if necessary, for securing the cutting of suitable groups in later periods by means of protective cuttings, or fringes, or for forcing the growth of young groups which have to be exploited before the proper time, and in order to obtain a general idea of the probable course of events.

The forecast for the next two periods might be somewhat as follows, but it would not generally be necessary to estimate the yield. There is no objection, as we have already seen in the example of Hartig's method, to cut the groups in the periods as shown above and on the next page.

The combined method will be best explained by an example. We will take for this purpose the pine series of the last example (page 187).

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compartment.	Area. Acres	Age at beginning of period.	Average age at time of cutting.	Yield per acre. Feet.	Total yield. Feet.	Yield of the affectation.	Average yearly yield.	Remarks.
[illegible]	1	15	25	1,850	1,850			1*b*. Pro tectiv cutting.
[illegible]	3	90	100	7,900	23,700			
[illegible]	5	80	90	7,500	37,500	494,950	24,748	
	50	70	80	7,000	350,000			
[illegible]	13	60	70	6,300	81,900			

The allotment of groups to the next two periods should be ascertained roughly, so as to enable the organizer to adopt measures, if necessary, for securing the cutting of suitable groups in later periods by means of protective cuttings, or fringes, or for forcing the growth of young groups which have to be exploited before the proper time, and in order to obtain a general idea of the probable course of events.

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II. 21—40	73·33	62·00	...	11·33
III. 41—60 and over	73·34	83·00	9·66	—

In the first age-class, a blank of 5 acres is included in the above. This class is very fairly represented.

As regards the other two, the surplus quantity of the older class will more than compensate for the deficit in the second class, and we might safely put the full area of 73·33 acres into the first period, or even more, considering how much over-mature timber there is. To be on the safe side, there being a marked deficiency in the second class, and to better equalise the yield, we will put down only 72 acres.

We shall then have the following estimated yield for the first period :—

Compartment.	Area. Acres	Age at beginning of period.	Average age at time of cutting.	Yield per acre. Feet.	Total yield. Feet.	Yield of the affectation.	Average yearly yield.	Remark
1*b*	1	15	25	1,850	1,850			1*b*. Pr
5*b*	3	90	100	7,900	23,700			tecti
2*b*	5	80	90	7,500	37,500	494,950	24,748	cuttin
8	50	70	80	7,000	350,000			
7*b*	13	60	70	6,300	81,900			

The allotment of groups to the next two periods should be ascertained roughly, so as to enable the organizer to adopt measures, if necessary, for securing the cutting of suitable groups in later periods by means of protective cuttings, or fringes, or for forcing the growth of young groups which have to be exploited before the proper time, and in order to obtain a general idea of the probable course of events.

The forecast for the next two periods might be somewhat as follows, but it would not generally be necessary to estimate the yield. There is no objection, as we have already seen in the example of Hartig's method, to cut the groups in the periods as shown above and on the next page.

Period.	Sub-compartment	Area of acres.	Age of group at commencement of period.	Average age at time of cutting.	Yield per acre.	Total yield.	Yield of affectation.	Average yearly yield.	Remarks.
II	*7b*	4	80	90	7,500	30,000	447,800	22,390	*1b.* One acre of this was cut during first period.
	9c	8	70	80	7,000	56,000			
	9a	30	60	70	6,300	189,000			
	4a	32	50	60	5,400	172,800			
III	*1b*	9	55	65	5,850	52,650	378,150	18,908	
	6b	10	55	65	5,850	58,500			
	7a	18	45	55	4,900	88,200			
	3c	20	45	55	4,900	98,000			
	7c	12	45	55	4,900	58,800			
	9b	5	40	50	4,400	22,000			

The above is a very favourable case on account of the great quantity of old timber, which enables us to maintain normal affectations throughout, and yet never to cut a group below its exploitable age, and this in spite of there being a deficiency of over 11 acres in the area occupied by groups of the second age-class. If there had been, say, 74 acres of the third age-class, but only 40 of the second, we should not have been justified in cutting as much during the first period; certainly, in that case, not more than 60 acres should have been entered in the first affectation.

The Austrian Method.

I call this the "Austrian Method," because it was first published, in a modified form, by the Austrian

Government, in 1778, in a decree regulating the cutting of wood in State-forests, and because Austria is the only country of importance which still adheres to the system.

Let Y represent the annual yield: I the annual increment: Q the actual quantity of standing stock: Q' the normal quantity: r the revolution: then, by this method,

$$Y=I+\frac{Q-Q'}{r}*$$

That is, the yearly increment is to be cut annually, provided that $Q=Q'$. But if Q is greater than Q', a yearly quantity equal to the rth part of the difference must be added to I; and if Q is less than Q', the rth part of the difference must be deducted from I.

Evidently the intention was to attain the ideal state at the end of the revolution; but it was a fallacy to imagine that this would necessarily be effected within one or any given number of revolutions. The normal state could be attained only in the event of the age-classes being all properly represented at the end of the revolution, but the abnormal contents of a series might easily be equal to the normal contents without the age-classes being equally represented.

The contents, Q', of the ideal forest were originally estimated for each group, or age-class, in the manner described at page 38; *i.e.*, the mean yearly growth of the annual cutting for the revolution fixed, was taken as the mean yearly growth of the groups of each

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* The original formula was somewhat different to this, the one now generally used and first propounded by C. Heyer in his *Waldertragsregelung*, published in 1840.

age-class. The actual supply of the forest, Q, was also calculated by means of the mean annual growth of the annual cutting. As this method gives very inaccurate results, the value of Q' is now generally estimated by means of local experiential tables, and that of Q is accurately determined by direct measurements. Formerly all that was needed was to determine the average yield of an acre of land cropped with trees r years old, and the average ages of the trees in the several groups. The mean yearly yield of the former $\left(\frac{c}{r}\right)$ was then taken as the average growth per acre of every group. The present system is, therefore, much more elaborate, but also much more accurate.

The yield of the pine series, described at page 187, would be calculated as follows :—

The normal area of the annual coupe $=\frac{220}{60}=3{\cdot}67$.

The yield of a group 60 years old is 5,400 cubic feet per acre ; therefore the normal annual cutting in this case will amount to $5{,}400\times 3{\cdot}67=19{,}798$. The contents of the ideal forest would be

$$10\left(700\times 3{\cdot}67+2300\times 3{\cdot}67+3300\times 3{\cdot}67+4400\times 3{\cdot}67+\frac{5400\times 3{\cdot}67}{2}\right)+\frac{5400\times 3{\cdot}67}{2}=501689 \text{ ft.}=Q'.$$

(See pages 190 and 36.)

The actual supply of wood is (by the experiential table at page 195) :—

Sub-compartment.	Contents, cubic ft.	Mean Yearly Growth.
5*b*	22,500	250
2*b*	35,000	438
8	315,000	4,500
7*b*	91,800	1,530
9*c*	35,200	704
9*a*	99,000	2,475
4*a*	73,600	2,453
1*b*	10,500	700
6*b*	10,500	700
7*a*	6,300	1,260
3*c*	7,000	1,400
7*c*	4,200	840
Total	710,600 = Q.	17,250 = I.

The mean yearly yield of groups under 20 years of age is taken as the same as that of groups 20 years old. Therefore,

$$Y = 17250 + \frac{710600 - 501634}{60}$$

$$= 17250 + 3483 = 20733 \text{ ft.}$$

In this fraction, r may, of course, be made equal to any number of years instead of exactly the number in the revolution. The time required to arrive at a normal quantity of standing stock would be proportionately lengthened or shortened. If we put $r = 50$, the time required would be 50 years; if we put it equal to 100, the time required would be 100 years.

Several other formulæ for finding the annual yield of a forest based on the normal quantity of wood, have been proposed. Hundeshagen, for instance, proposed to find the annual yield by the proportion $Q' : Y' = Q : Y$, whence

$$Y = \frac{Y'}{Q'} \times Q.$$

When Y' = the ideal yield.

This formula also leads, sooner or later, to the establishment of the normal quantity of standing stock. For Y can only be equal to Y' if $Q = Q'$; but if Q is less than Q', then $\frac{Q}{Q'}$ is a proper fraction, and the quantity to be cut will be proportionately reduced; if Q is greater than Q', the quantity of material to be cut annually will be proportionately greater than Y'.

Theoretically, there is little to object to in the Austrian method. If the cuttings are always taken from the oldest groups, the age-classes must sooner or later become normal. A decided practical objection to it, is that everything depends on the correctness of the estimate of increment, which is a most uncertain and varying factor, and cannot be ascertained with that accuracy which the case may demand. This is a fatal objection, and applies equally to all methods based on the ideal supply, including the cruder formulæ of Hundeshagen and others.]

The Financial Method.

By this method groups are treated separately, and cut as soon as financially exploitable, without reference to a sustained yield. The financial maturity of a group is fixed in the manner described in the chapters on the determination of the financial exploitability of a group. (See pages 69 and 17.)

In a continuous series of seedling-forest this method could not always be thoroughly carried out, if due weight is given to a proper sequence of cuttings; but for isolated groups there would be no physical obstacles to its being carried out to the letter.

In order to find out if a group is financially exploitable, we should know approximately

(1). The value of the land.

(2). The value and date of receipts of thinnings, past and future.

(3). The present and future value of the group.

(4). The cost of cultivation.

(5). Annual cost of supervision, taxes, &c.

These being known, the relative exploitability of a group may be ascertained by formulæ described in Chapter X.

It will seldom happen that all of the first four items can be accurately ascertained. Information regarding past thinnings will often not be forthcoming at all, and the quantity of future thinnings will always be more or less hypothetical. Rough estimates must be made if accurate data are not to be had.

The present value of the group should be estimated as accurately as circumstances admit; if possible, by Draudt's method. The future yield should also be estimated as accurately as possible by felling sample-trees, and calculating their growth, the present percentage of each description of wood being taken as that of the future yield, or by local increment-tables. (See pp. 107 and 131.)

As a rule, only older groups would be examined about whose exploitability there was some doubt. There would be generally none as regards young and very old groups. The estimate would be for a period of not more than ten, or, at the most, twenty years. It will, therefore, be often possible to take

the mean yearly increment as a basis for the estimate of future yield. The increment of the branches, at all events, will have to be calculated in this way if experiential tables are not available.

If Draudt's method is not adopted, the proportion of each description of wood must be deduced from the results of previous cuttings. It is essential that this point should be ascertained as accurately as possible, because the value of the increment will sometimes not depend nearly so much on its quantity as on its quality.

Having arrived at an estimate of the five items, the Index may be calculated in the manner described in Chapter X.

Judeich's Modification.

The above method of treating each group separately would evidently be impracticable in continuous masses of forest. It would necessitate, at least, the cutting of a main ride round each group, so that perhaps half or more of the area would be taken up by rides. Again, the exigencies of the market, especially when the forest is large, and the supply of produce limited to the requirements of the immediate neighbourhood, may render it necessary financially, and politically if the forest is State property, not to flood the market with produce at one time and stop the supply altogether at another. In such circumstances, which are the rule in well wooded districts, it is desirable in every respect to maintain a tolerably uniform supply. Oberforstrath Judeich has, therefore, elaborated a system similar

in form to the combined method, which is better suited to the general requirements of large seedling-forests.

He first of all draws up a table similar to the one at page 200, showing the area actually occupied by each age-class, and the area it would occupy if the age-classes were normal. He then selects for cutting first the following descriptions of group, but not necessarily in the order named :—

(1). All groups, or portions of groups, which must be cut, in order to ensure a proper order of cuttings (protective cuttings) or which are necessary for the proper management of the forest generally (*e.g.* clearings for roads).

(2). All groups which are undoubtedly exploitable —that is, whose indices have fallen below the rate required.

(3). Groups whose exploitability is doubtful. These need not be considered, unless it is thought desirable that they should be cut during the next ten or twenty years to make up the yield.

The normal coupe is the chief regulator of how much area should be worked. The area of the normal coupe is determined, of course, by the length of the financial revolution. It would be 3·67 acres for the example at page 200, if the most advantageous revolution for the series generally was found to be about sixty years; more or less would be taken, according as there was an excess or otherwise of exploitable timber. The plan of cuttings for the next ten or twenty years would be drawn up on these general lines.

For the series of pine described at page 187, if the financial revolution were found to be about sixty years, the annual ideal coupe would be 3·67 acres, and the sum of the coupes for twenty years would be $3·67 \times 20 = 73·4$ acres. The groups that would naturally come first according to age are those in 5*b*, 2*b*, 8, and thirteen acres of 7*b*. One acre of 1*b* must also be entered, as, although the group in it is only fifteen years old, the protective cutting there cannot be postponed. All other groups mentioned above will be undoubtedly exploitable by the time their turn to be cut comes; but, by way of illustration, we will assume that there is some doubt in this respect as regards the group in 7*b*, and proceed to calculate its index.

It is estimated that the financial revolution is sixty years, with a return of 3 per cent. on outlay. If, therefore, the index of a group has at any time fallen below 3, then it is decidedly exploitable.

Direct information is not available regarding past thinnings, but there is reason to believe, on the ground of results obtained elsewhere under similar conditions, that their value amounts up to the present time to about 10 per cent. of the value of the main cutting.

The value of the main cutting is estimated to be 2,500 shillings per acre for a group sixty years old, 4,000 for a group sixty-eight years old, and 5,300 for a group seventy-eight years old. The yearly-recurring expenditure amounts to two shillings per acre, and the cost of cultivation was twenty shillings per acre.

We know that the maximum prospective value of the land is calculated for a revolution of sixty years.

The value of the land per acre is, therefore, at 3 per cent. interest (by the formula at page 18),

$$\frac{2500 + 250 - 20 \times 1{\cdot}03^{60}}{1{\cdot}03^{60} - 1} - 66{\cdot}7 = 471 \text{ shillings},$$

when $H_{60} = 2500 \ : \ \Sigma(D) = 10\% \ H_{60} = 250 \ : \ c = 20$

$$V = \frac{2}{0{\cdot}03} = 66{\cdot}7.^{*}$$

We are now in a position to calculate the index by means of the formula at page 71; and will have, if there is a prospective thinning per acre of the value of 100 shillings, in the seventieth year,

$$H_{68} = 4000 \ : \ H_{78} = 5300 \ : \ p = 3 \ : \ B = 471 \ :$$
$$D_{70} = 100 \ : \ V = 66{\cdot}7.$$

Therefore,

$$p' = 100\left(\sqrt[10]{\frac{5300 + 100 \times 1{\cdot}03^{8} + 471 + 66{\cdot}7}{4000 + 471 + 66{\cdot}7}} - 1\right)$$
$$= 2{\cdot}8.$$

The index, therefore, will have fallen below 3, and the group is consequently exploitable.

Oberforstrath Judeich thinks that it will suffice for all purposes if thinnings are estimated roughly at so and so much of the main-cutting. Of course the value of the land depends greatly on the time of receipt and the value of the thinnings; but, as this term appears in both denominator and numerator of the index, a certain latitude may perhaps be permitted.

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* The maximum prospective land-value will, of course, vary according to station. But for all practical purposes it should suffice to determine the most advantageous revolution for a few average groups of a series, and to calculate the value of the land throughout accordingly.

The yearly cutting for the above series during the first twenty years might then be calculated in precisely the same way as by the combined method. The procedure recommended by Judeich is, in fact, precisely the same; with a large stock of over-mature timber there would be no objection, if other circumstances did not militate against such a measure, to cut more than the average yield at first, and less towards the end of the term; or, conversely, to cut less, and keep financially over-mature groups standing.

If, in the above example, there had been a dearth of trees of the second age-class, it would have been necessary by this method, too, to husband the supply of the oldest by cutting a proportionately less quantity during the first twenty years, so as to avoid cutting trees of the younger age-class long before the proper time.

On the whole, the ultimate result of Judeich's method is very much the same as that of the combined method, provided the financial revolution is kept in view in the latter case also. By the former method, however, we must make laborious calculations regarding the financial exploitability of certain groups. Having done this, and shown that they are undoubtedly cumbering the earth and should be removed at once, we are told that cannot be; considerations of demand, labour, sequence of cuttings, and so forth, demand that they shall be gradually taken away.

It appears, then, that for large expanses of forest in which the general requirements must be considered first of all, and those of individual groups last, the forester may well be spared the more laborious procedure involved in Judeich's method. For isolated

groups in which a tolerably uniform yield is not a necessity, the financial system, pure and simple, is certainly to be preferred by the proprietor who wishes to utilize his land to the greatest advantage.

Choice of a Method.

As we have seen, the Austrian and allied methods, as well as Hartig's, are founded on uncertain data, and have no means of preventing excessive cuttings. This check is obtained by the method of compartments whose first canon is that equal areas shall be couped yearly, and only the groups of an affectation be cut during the corresponding period. But this method may demand too many sacrifices in seedling-forest, if rigorously carried out, as it fixes the area and location of the annual coupe without due regard to the state of the groups to be cut, or the forest generally.

The financial method of treating each group separately may be practicable in the case of isolated groups, but is generally unsuited to large expanses of forests, in the regulation of which the ultimate object will almost always be a more or less uniform yield. Judeich's modification of the financial method certainly effects this object in a rational manner, but appears to be unnecessarily complex, and, on the whole, not more likely to lead to satisfactory results than the simpler combined method, always provided that the financial revolution is adopted. As a general rule, therefore, it appears that the combined method is the one best suited to large tracts of seedling-forest, whose groups must be worked with reference to the whole, whilst

for coppice and underwood of all descriptions the simplest and best plan is to adopt the method of equal areas, as the objections which apply so forcibly to it in regard to seedling-forest, do not, as we have seen, hold good in the case of forests subject to very short revolutions.

CHAPTER XXI.

METHODS OF DETERMINING THE YIELD OF FORESTS COMPOSED OF VERY IRREGULAR GROUPS.

THE kinds of forest it is necessary to consider under this heading, are composite forest and primitive forest.

1. COMPOSITE FOREST.

Here two distinct modes of treatment are necessary, one for the underwood and another for the overwood.

The underwood, as we have seen, may be most conveniently treated by the method of equal areas, or of areas inversely proportional to their supposed productive power. The former will generally be found sufficient for all practical purposes.

The theoretical considerations on which the yield of the overwood in a forest may be based, were examined at page 41.

Having determined the most advantageous revolution, the next thing is to decide the amount of cover which the underwood will bear with advantage. This will depend on the species constituting the underwood and those constituting the overwood: on the station, and on the local value of coppice as compared with standards.

In the next place, the cover, cubic contents, and heights of representative trees of each age-class must be fixed, with the exception of the youngest, which

stocked; but the last yearly coupe, or coupes, which is regularly re-stocked, should be entered in the first class.

The Number of Years necessary to realize the Ideal State.

An effort should be made to effect a practically normal state of the age-classes of a series by the end of the first revolution, or within the term of years required to work through the whole forest. It may not, however, be advisable to accomplish this so quickly in forests in which the age-classes are very abnormal, as due regard should always be paid to the money question. It would generally be advisable, for instance, to exceed at first the normal coupe considerably, in a series of three age-classes, of which the first two were largely overstocked, and to reduce the annual coupe below the normal if they were considerably understocked.

Periods.

Very short periods are apt to hamper the executive, especially in forests naturally regenerated by seed, where greater freedom in locating the cuttings is necessary than in forests which are independent of "seed-years," and can be regenerated with much greater certainty, regularity, and rapidity.

Another objection to very short periods is that they make the gradations of the age-classes too small.

On the other hand, very long periods are apt to allow too much licence to the executive in carrying out the provisions of the plan.

Five to twenty years may be taken as limits. Thirty years was formerly the usual term for forests with long revolutions; twenty is now more general for seedling-forests, naturally regenerated, and ten for those regenerated by the method of clean cuttings, or, what comes to the same thing, the twenty-year periods are divided into sub-periods of ten years each.

AFFECTATIONS.

Generally speaking, the affectations should be of about equal area.

The system of allotting to each period an area inversely proportional to its supposed productive power, has not been found to answer. It necessitates, to be of any use, the determination not only of the quantity of produce a given area will yield in a given number of years, but also its quality. The latter will vary with the quality of the station, and it will, therefore, be necessary to know not only the number of cubic feet of wood a given class of land will produce, but also their quality; a question already extremely difficult is, therefore, rendered doubly so by this additional element of uncertainty.

But if only land of about the same fertility is put into the same series, differences of station will probably counterbalance each other during a period, and there will be no need to resort to uncertain expedients to effect an equalisation of the periodical yields.

ALLOTMENT OF GROUPS TO AFFECTATIONS.

As a rule, the oldest groups should be cut first. Circumstances will, however, often prevent this

arrangement. If we had, for instance, to choose between two groups, one old but vigorous, the other comparatively young, but sickly from mismanagement, attacks of insects, damage by fire, &c., or on account of the species being unsuited to the station, we would probably elect to cut the younger group first.

Again, in order to obtain a proper sequence of cuttings it may be necessary to cut younger groups before older ones; or in order to avoid having very large areas stocked with groups of about the same age where there is fear of damage by wind; or for other reasons.

Protective Cuttings.

These are very important in forests in situations exposed to violent storms, especially in coniferous forest. As we have already seen, they consist in clearings 30 ft. or more broad, made on the weather side of a group when it is young, so as to avoid the danger of suddenly exposing it to wind and sun, when the group in front of it is cut. The area thus cleared may be re-stocked with young growth, which then forms a protective fringe, or it may be left bare.

The usefulness of these protective cuttings in saving groups from premature cutting is very great, and the principal reason why it is advisable to obtain at the beginning a rough idea of the course of the coupes during the whole of the revolution. The age up to which protective cuttings may be safely made in a group depends on the kind of tree, the conditions under which it is growing, and the station. Some

species withstand wind much better than others: conifers, especially those with only tracing roots, must be most carefully dealt with.

EXTRAORDINARY THINNINGS.

These will be indicated when it is necessary to cut a group before its exploitable age, in order to hasten its growth, or its seed-producing power in case the group is to be naturally regenerated. When the thinning is very severe, it will often be advisable to introduce young-growth of shade-enduring species in order to protect the soil. If the group is cut within the next 20–30 years, this young growth may sometimes be utilised to re-stock the ground when the overwood is cut away.

UNIFICATION OF SUB-COMPARTMENTS.

Groups in a compartment should, if possible, all be subjected to the same revolution. If this cannot be managed at once, it will often be possible to effect a change of species, sooner or later, which will bring about the desired result.

CHAPTER XXIII.

PREPARATION OF THE PLAN OF OPERATIONS.

This is intended to furnish the *raison d'être* of the proposed general plan of management, together with detailed instructions for the next ten or twenty years. It should, therefore, commence with a general description of the forest and of the circumstances which have led to the proposed system of management. This account will be compiled from the facts collected during the examination of the forest. It should be condensed; only essential points being noted in order that the leading features may not be obscured by a mass of detail.

It may be divided into the following headings:—

1. The Actual State of the Forest and its Environment.

This should comprise a condensed history and description of the forest:—General topography, station, and tenure; prevailing species; past management, expenditure, and receipts. Circumstances affecting its general management, such as the requirements of the surrounding population, markets, rights, and privileges, the existence in the vicinity of industries requiring a steady supply of forest produce. Reasons

for the system of differentiation and roads adopted. State of crime and means of prevention.

2. CIRCUMSTANCES AFFECTING THE YIELD.

Reasons for the series and revolutions chosen; and for changes, if any, of régime or species. Reasons for the method adopted for determining the annual yield. Methods employed in estimating contents of groups. The period which must elapse before the ideal state will be approximately attained. Circumstances not now affecting the value of the produce but likely to do so, such as the construction of new or improved lines of communication, the starting of new industries (mines, factories, &c.). Directions in regard to the general management of the forest; such as directions as to the mode of carrying out the main-cuttings, thinnings, draining, and cultural operations. Reasons for alterations, if any, in the executive or protective establishments.

3. YIELD.

General statement of past and estimated future annual yield from main-cuttings, thinnings, and minor produce (all separately.)

4. ANY OTHER IMPORTANT POINTS BEARING ON THE MANAGEMENT OF THE FOREST.

(See also Chap. XVIII. on this subject.)

The plan of operations should include the following:—

(1). General Plan.

(2). Statement of boundaries (in the form shown at p. 172).

(3). Of compartments and groups (in form p. 169).
(4). Of age-classes (form p. 171).
(5). Detail-plan of main-cuttings.
(6). Detail-plan of thinnings.
(7). Statement of total estimated yield.
(8). Regeneration and cultivation-plan.
(9). Maps.

GENERAL PLAN.

This is intended to give a general view of the present state of the forest, and its working for the next ten years, or for a longer period.

It may be drawn up in the following form for regular seedling-forest, underwood, and coppice. For forests exploited by the selection-method, and for the overwood of composite forest, obvious alterations are necessary; the number of trees of a class, for instance, takes the place of area, and the yield of the sample-tree of a class that of its yield per acre, and when the number of trees regulates the yield, columns will be necessary showing the numbers of each class to be cut; the column showing the age of groups will disappear, and generally, also that showing the area of sub-compartments, not only for these methods of treatment, but also for underwood and coppice.

The above statement is filled in tentatively at first, and transposition of groups made from one period or decade to another until a satisfactory arrangement is arrived at.

If there were other series in the range, mixed beech and fir, as in the example at page 182, for instance, separate statements should be made for each. A general statement may then be drawn up of the ope-

ANGE.

…RST PERIOD.—1884–2003.				Second period.—2004–2023.	Third period.—2024–2043.	REMARKS.
…de.	Second Decade.					
…eld …terial.	Area of Coupe.	Yield of Material.				
Total Yield.		Per Acre.	Total Yield.			
c. ft.	acres.	c. ft.	feet.	acres.	acres.	
–	1	2,300	2,300	–	9	
36,250	–	–	–	–	–	
–	T	–	–		20	
–	–	–	–	32	–	
23,100	–	–	–	–	–	
–	–	–	–	–	10	
–	T	–	–	–	18	
–	13	6,650	86,450	4	–	
–	–	–	–		12	
186,200	22	7,250	159,500	–	–	
–	–	–	–	30	–	
–	T	–	–	–	5	
–	–	–	–	8	–	
245,550	36	–	248,250	74	74	
24,555	–	–	24,825	–	–	

Remarks:

1*b*. Protective cutting.

9*b*. To be planted up at once with pine yearling seedlings, 4 feet apart, in lines 4 feet apart.

It is intended to re-stock 5*d*, 7 acres, now belonging to the beech series, with pine, with a view to bringing that sub-compartment into this series. The group now there is to be cut in the first period.

Underlined areas are those which are to be couped and re-stocked during the first period.

Those marked T are to be thinned.

The increment of groups was estimated by means of local experiential tables accompanying this statement.

rations to be carried out during the first period, or decade, for the whole forest.

Detail-Plan of Main-Cuttings.

This may generally be drawn up in the following form. But it will not always be possible to give the area; for overwood in composite forest and forest exploited by the primitive method, for example (see preceding page). In cases of natural regeneration, when the old crop is only gradually removed, it will suffice to put down in red ink an area proportional in size to the quantity of wood to be cut, making a note to that effect in the remarks-column (see also remarks, p. 223).

Detail-Plan of Main-Cuttings. 1st Decade 1883–1892.

Locality.	Compartment and Sub-compartment.	Area of coupe.	Species.	Age-class.	Quality class.	Cubic contents. Feet.	Remarks.
Red Hill	2*b*	5	Pine	III.	II.	36,250	2 *b*.—At beginning of decade.
Newman's Copse	5*b*	3	"	"	"	23,100	5 *b*.—Ditto.
Ringwood	8	28	"	"	"	186,200	Cuttings to proceed from east to west.
Total ...	...	36	...	...	...	246,550	
Average yearly Yield						24,655	

The above form should be on the left side of the sheet, and the following on the right. The proposed and the actual cuttings can then be most conveniently compared.

Main-Cuttings actually carried out.

Compartment.	Decade 1883—1892.																				Remarks.
	1883.		1884.		1885.		1886.		1887.		1888.		1889.		1890.		1891.		1892.		
	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	Area.	Quantity.	
5b	3	26,540																			Only 27 acres of compartment 8 were couped owing to windfalls in *7b* from which the full yield was made up.
2b	...	...	3·5	24,610																	
				etc.		etc.															
Total	3	26,540	3·5	24,610																	

The quantities should be shown separately for different qualities of wood (logs, poles, large firewood, spray, &c.), or at all events, logwood and firewood should be kept separate.*

Detail-Plan of Thinnings.

These should be scheduled in the same manner as the main-cuttings, the actuals and the estimate being recorded on opposite sheets.

As regards the quantity and quality of the intermediate cuttings, the usual plan is to make the estimate by means of experiential tables of average returns of groups of about the same age and of the same species. Much depends on previous treatment and on how a group originated; density and station are the most important factors to consider, and the results of previous experience should be modified as each case appears to require.

When neither local nor general tables exist, some data will probably have been collected during the examination of the forest which will serve as a guide.

Often thinnings have no value, or they are removed by right-holders, and cannot be calculated on. In such cases it is needless to observe that there is no object in estimating the quantity.

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* The classification adopted will, of course, depend on local circumstances. In many places firewood would not be classified at all, and what may be valuable only as firewood in one country, may be used for constructive purposes in another.

Statement of Total Yield.

This may be drawn up in the following form:—

Abstract of estimated total Yield for Decade 1883-92.

Aggregate area of coupes.	Main cuttings, cubic feet.				Thinnings, cubic feet.				Grand Total.
	Logwood.	Other wood.	Stumps.	Total.	Logwood.	Other wood.	Stumps.	Total.	
Total ...									
Mean yearly yield ...									

The sub-divisions of main-cuttings and minor-cuttings will always depend on local circumstances, and the above sub-divison into logwood, other wood, and stumps, is merely given by way of illustration. The above statement should be inserted on the left side of the sheet and the actuals on the right.

Regeneration and Cultivation-Plan.

This will comprise the filling up of blanks, cultivation of wastes, and regeneration of groups. The proposed plan should be written on the left side of the sheet and the details of its execution on the other.

The following form may be used :—

Left Side of Sheet.

CULTIVATION-PLAN.

FIRST DECADE 1883–1892.

Compartment.	Filling up of blanks.	Cultivation of wastes.	Regeneration of group.	Remarks.
1*a*	...	...	3	To be taken in hand at once.
2*a*	...	8	...	
	&c.	&c.		

Right Side of Sheet.

WORK ACTUALLY CARRIED OUT.

1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Total.	Remarks.
Area, Acres.											
3	...	...	...	...	...	...	...	...	...	3	Pine plantation 1 year seedlings at 4 feet distances.
8	...	...	...	...	...	...	...	...	...	8	Waste-stock. with alternate rows of pine and spruce at 5 feet distances.
		&c.		&c.							

MAPS.

The following maps will be required by the Executive :—

(1). Group-Map.
(2). Working-Map.
(3). Inspection-Map.

GROUP-MAP.

This map should be on a smaller scale than the original map; about four inches to the mile, $\frac{1}{15840}$, will generally suffice. The group should be shown in colours, each kind having a different colour, and each age-class having a certain depth of colour, the youngest age-class being lightest, and the oldest darkest. A good general idea of the proportion of age-classes and species of the forest is thus obtained at a glance.

WORKING-MAP.

This should be a copy (of course without lines of construction) of the original map, on the same scale, and not coloured. It will be required for detail work, such as boundary-mark inspections and measurements, and should not be on a scale of less than 8 inches to the mile, $\frac{1}{7920}$.

INSPECTION-MAP.

This map is required for general purposes, such as inspections, and should, therefore, be made of convenient size, on a scale which may be made the same for all forests belonging to one proprietor, or to depend on the size of the range. The 4-inch

scale, $\frac{1}{15840}$, is a convenient size. The boundary-marks are not shown in this map, as it is not generally large enough for that purpose; but all rides, roads, compartments, sub-compartments, streams, and general features of the country should be filled in.

5. Booking Results and other Details.

A yearly record should be kept by the Executive of

(1). Changes, if any, affecting survey-details.

(2). Details of cuttings, actual and proposed, for main-cuttings and thinnings, in the forms given above.

(3). Details of cultivation actual and proposed in the forms given above.

(4). Comparative abstract, showing the estimated and actual quantity of cuttings, together with the sums realised by their sale.

(5). General abstract of receipts and expenditure.

(6). Estimated and actual quantity of, and receipts and expenditure on account of, minor produce.

(7). Abstract of average gross and nett value of a cubic foot of wood, arranged according to species and régime.

Changes affecting Survey-Arrangements.

The chief points to note are changes of absolute area on account of sales, purchases, exchanges, &c. Relative increase or decrease in the area of stocked or unstocked land, on account of rides, roads, stocking of wastes, newly-acquired land, &c. Alterations of boundary-marks, or their loss. Alterations which do not affect the relative proportion of stocked to un-

3. *Total Yield.*

The same form as the above, containing the sum of main-cutting and thinnings.

GENERAL ABSTRACT OF RECEIPTS AND EXPENDITURE.

This is intended to show at a glance the gross and nett yield of the forest, and may be drawn up in the form opposite, subject to such modifications as circumstances may require.

ESTIMATED AND ACTUAL QUANTITY OF, AND RECEIPTS AND EXPENDITURE ON ACCOUNT OF, MINOR PRODUCE.*

This statement may be drawn up in the following form. When the receipts are small, or the produce is sold in a lump for the whole forest, the information contained in the remarks-column of the General Abstract will suffice, and this detailed statement be dispensed with.

Year.	Compartment.	Produce estimated.			Actuals.		The estimate is, as compared with the actuals,			
		Description.	Quantity.	Value.	Quantity.	Value.	Quantity. Too much.	Quantity. Too little.	Value. Too much.	Value. Too little.
1883	Whole forest	Right of grazing in compartments not in fence.	...	700	...	975	...	...	...	275
				&c.	&c.					

* *Minor produce* is all produce not woody (fruit, game, &c.).

	Nett return.		Remarks.
Total.	Total.	Per acre.	
	Shillings.		
6,591	12,950	56	1883.—The minor produce sold consisted of the following items, and was collected and removed by purchasers themselves. Beech-mast 25 shillings. Grass . 975 ,, Total . 1,000

SECTION VII.—REVISIONS.

At the end of each period, or sub-period, the general plan of operations will have to be revised, and detail-plans framed for working the forest during the following period or decade.

Sometimes serious calamities, such as damage by insects and wind, will render an earlier revision necessary, and in forests worked intensively, or which are very irregular, it is generally advisable to have intermediate revisions at intervals of five years.

Principal Revisions.

The points to consider are (1). How the actual results compare with the estimate, and how the proposed plan has answered during the past period or decade. (2). The preparation of a new plan of operations for the next period or decade.

As regards the first point, it will be easily answered if the records have been properly kept, by comparing the estimate and the actuals. Each item (main-cuttings, thinnings, minor produce, etc.) should be taken, seriatim, and carefully examined. Mistakes in the original plan, or in the manner of carrying it out, will thus be brought to light, and steps can be taken to avoid their recurring, if possible, during the next period. An examination of the work done in the forest will show whether the cuttings were suitably located and their sequences satisfactory; and also if other works, such as those of regeneration, road-

making, and cultivation, have been satisfactorily carried out in accordance with the plan, and with what results.

Before commencing to prepare a fresh plan for the next decade, or period, the map and statements should be corrected so as to show the present situation. Sub-compartments, for which there is no longer any occasion, will be done away with on the map and in the statements; and if new land has been taken up it will be apportioned to existing compartments, or made to constitute new compartments. It is well to prepare an entirely new map of groups.

It will then be necessary to make an entirely fresh examination and assessment of the forest, or, at all events, of groups which it is intended to fell during the next period. A detail-plan of operations based on this estimate is then drawn up for the coming term in precisely the same manner as the previous one, but it will not be necessary to repeat the general description which preceded the plan for the first period. A few introductory remarks will suffice to call attention to changes which may have occurred, and to the results of the working of the forest during the past period.

Intermediate Revisions.

The object of these is to show how the plan of operations has worked, and to make such alterations within the prescribed limits of the original plan as appear necessary, but neither fresh assessments of groups, nor a working plan for the next decade or period is made. The scope of intermediate revisions is, therefore, much more limited than that of principal

revisions, and they partake more of the nature of an inspection than of a revision. They are, therefore, most useful in forests such as those belonging to the State, in which the work of the executive is controlled by superiors. They are also useful in cases in which unforeseen circumstances, such as windfalls on a large scale, or the sudden demand for a particular kind of produce, necessitate a change of working. It will then be a question whether an entirely new plan should be framed or not, or if the old one can be altered sufficiently to satisfy the new conditions.

SECTION VIII.—CONVERSIONS.

Coppice, and forests which have been treated by the primitive or composite method, have sometimes to be converted into regular seedling-forest. Considerations of sylviculture might render such a conversion desirable, as when the impoverishment of the soil necessitated a change of species and system (*e.g.* from deciduous to coniferous forest). Other considerations, again, may necessitate a change, such as questions of finance, or the wish to attain a more simple and regular system. Generally speaking, the composite method is not suited to forests worked extensively, nor to those which are directly managed by men lacking intelligence, or a thorough knowledge of forestry. The principal objection to the primitive method is the difficulty of determining the sustained yield and of ensuring the regeneration of the forest.

Grebe* divides the material to be exploited in the conversion of primitive or composite forest into regular seedling-forest, into

(1). Main-cuttings of the groups to be converted.

(2). Improvement-thinnings of original standing stock, or cuttings which prepare the way for the main-cuttings.

(3). Thinnings of converted groups.

The forest should be divided into affectations of equal or nearly equal area. The same author gives, as an example, the case of a composite forest to be converted in four periods to regular seedling-forest, allotting groups to affectations in the order shown below.

1st Period.

1. Groups which are thoroughly exhausted to be cleared off, and the ground restocked artificially.†

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* *Die Betriebs und Ertragsregelung*, p. 307.

† Not necessarily cut "clean." In moist, tropical climates that would mean a growth of grass several feet high in the following year, which would be a great danger if left, and often a great expense if removed.

Excepting under specially favourable conditions, such as may be found at high elevations, the chief obstacles to regeneration in India, and probably tropical climates generally, are: drought in the hot weather, which is almost sure to kill numbers of young seedlings planted out in the open unless they are watered—an expensive affair—and a more or less luxuriant growth of grass on bare land and in open forest, which may catch fire and burn them up unless removed. The expense of cutting this grass may be, and probably generally is, very great, and cost much more than the prospective money-value of the plantation. There is the alternative in this case, however, of burning a fire-path all round the plantation to prevent fire from without, and of protecting the young growth by a vigilant look-out within. The outlay must in any case be liberal for effective protection, while the results are extremely uncertain, so far as I have been able to ascertain. In Europe, one of the chief obstacles

2. Groups with tolerably dense young-growth (underwood), consisting mainly of vigorous seedling or coppice-shoots of hard-woods. Most of the latter to be allowed to stand and grow into high forest.

2nd Period.

3. Groups of sufficient overwood to allow of a preparatory cutting for natural regeneration being made, but mostly deficient as regards underwood.

3rd Period.

4. Groups whose overwood is too sparse for a preparatory cutting, and which will, therefore, have to be prepared for it by improvement-cuttings and the retention of a large supply of stores.

4th Period.

5. Groups which are deficient in both over and underwood, but which can be sufficiently prepared for regeneration by filling up blanks during the first period, and by retaining a large number of stores from the underwood.

6. The wastes and coupes, stocked during the first period, if necessary.

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to natural regeneration is the precarious and more or less rare occurrence of what is called "seed-years," which become more and more uncertain and infrequent the farther north we go; and this is partly the reason why artificial regeneration is so much in favour in northern countries. In India most important species produce annually, after the age of fifty years or less, a good crop of fruit. This, and all other considerations, point to the advantage of having recourse in that country to natural regeneration, or, failing that, to artificial cultivation under the protection of foster-trees whenever practicable.

The course of the cuttings, as above arranged, would then be somewhat as follows :—

*Period.	Groups under Headings (1) and (2).	Groups under (3).	Groups under (4).	Groups under (5) and (6).
I.	Regeneration cuttings.	Preparatory cuttings.	Improvement cuttings.	Improvement cuttings.
II.	Improvement cuttings and thinnings	Regeneration cuttings.	Preparatory cuttings.	Improvement cuttings and thinnings
III.	Thinnings.	Improvement cuttings and thinnings	Regeneration cuttings.	Preparatory cuttings.
IV.	Thinnings.	Thinnings.	Improvement and thinnings	Regeneration cuttings.

The above example will serve to indicate the general course which events may be expected to take, but each case will have to be treated according to its special conditions.

The yield for the first ten years will have to be estimated by an examination of the growth and contents of each group, or portion of a group, to be cut during the next decade, and a plan of operations drawn up similar to that already described for forests exploited by the combined method. It will not, however, be necessary to attempt to estimate the contents and increment of any groups beyond

those which are to be worked during the first decade.

The improvement-cuttings will, of course, include the removal of very old standards which are not suitable for natural regeneration, and it will, therefore, often be difficult to avoid felling an excess of large timber during the first period.

The groups of later periods should be fixed provisionally, as the soundness of the plan for the first period will thereby be more generally demonstrated. But as time goes on, it may be found necessary to transpose groups from one period to another, it being impossible to predict positively which groups will be most suitable for regeneration twenty or thirty years in advance. At the revisions every five or ten years the executive should bring to the notice of the revising officer alterations which appear advisable in this and other respects.

The general principles to be followed in converting other kinds of irregular forest to regular seedling-forest are the same as for composite forest. The worst groups, and those most suitable for regeneration, are cut first, and the rest "improved." A more simple plan is to regenerate the entire forest artificially, but that is not always a feasible one; it is always a much more expensive method.

PART III.—MISCELLANEA.

CHAPTER XXIV.

INSURANCE-GROUPS, OR RESERVE-FUNDS.

Insurance-Groups are groups specially set aside for the purpose of making good any deficiency of material which may arise from unforeseen circumstances, such as an excessive estimate of the quantity to be exploited, losses owing to fire, insects, windfall, and so forth. They have not been found to answer. If taken from amongst exploitable groups with the intention of substituting from time to time younger groups, the arrangement interferes with a proper plan of cuttings; whilst, if they are chosen from younger groups, there is always the chance of their not being exploitable when required.

Several other expedients for establishing a reserve fund have, therefore, been resorted to, such as lengthening the revolution beyond the proper term, reducing the estimated yield so and so much per cent., neglecting the increment of groups to be cut during the first period, &c.

Of these, the plan of lengthening the revolution, or of deducting a certain percentage from the estimated yield appears to be the least objectionable; but these

and all others involve a sacrifice of revenue, and it is therefore difficult to understand why a certain loss should be incurred in order to avoid a possible one. The case is not at all analagous to that of an industrial undertaking in which a reserve-fund is formed. In the latter case no loss is incurred by the formation of a reserve-capital, which is invested either in the business itself, or in other funds, producing interest at the full market-rate, in proportion to the security it affords; whereas in forests the reserve-fund is invested at a lower rate of interest in funds, *i.e.*, forest, which do not offer greater security than if they were made to return the proper rate on capital-outlay. How this question is decided may not be a matter of very much importance; but as the principle of establishing reserve-funds in forests appears to be wrong, the simplest and best plan is evidently to dispense with them altogether.

CHAPTER XXV.

ORGANIZATION OF THE PERSONNEL.

THIS will depend in a great measure on the extent of the forests concerned. It is evident that the degree of division of labour which is possible in the management of forests comprising a million acres could not be applied with advantage to an estate of a thousand acres, and that private individuals will seldom be in a position to adopt the elaborate systems followed in the State-forests of European countries.

The following plan is that usually adopted for the management of forests of large extent, such as those of most European countries:—

The establishment consists of an inferior and a superior branch.

The former consists of (1) guards and (2) rangers.

(1). GUARDS, OR UNDER-FORESTERS.

The duty of these is, as the name implies, in the first place, protective. But, besides this, they are employed in the executive work of their beats, as, for instance, in supervising works of regeneration and felling.

(2). RANGERS,

Or, Range-foresters, have immediate charge of the executive work of a *range*, and are responsible for its proper conduct to the assistant-conservator.

The superior branch consists of (1) Assistant-Conservators, (2) Deputy-Conservators, (3) Conservators, and, in certain cases, of (4) an Inspector-General.

(1). Assistant-Conservators.

An Assistant-Conservator has charge of several ranges, called, collectively, a *subdivision*. Besides the general management of the work of the subdivision, the accounts of each range are audited, and have to be passed by him before payment is made.

(2). Deputy-Conservators.

A Deputy-Conservator has charge of several subdivisions, called, collectively, a division. His duty is purely to control, and he does not, as a rule, interfere with the executive work of the Assistant-Conservators; but it is his business to see that the general provisions of the sanctioned working schemes and yearly budget of his division are properly carried out, and to audit and pass the accounts of the subdivisional officers.

(3). Conservators.

A Conservator has general control of several divisions, collectively called a *circle*, comprising all the forests of the State, or, if they are very extensive, of a province only. He is the immediate adviser of Government in all forest matters concerning his circle; holds, in fact, in this respect, much the same position as an Under-Secretary of State, and usually has his head-quarters at the seat of government.

(4). Inspectors-General.

An Inspector-General stands in the same relation to a supreme government as a conservator to its local government, and exercises a general supervision over the whole system of a country.

It will be observed that by this system the administration is divided into an executive and a controlling branch, the former consisting of Assistant-Conservators and their subordinates, and the latter of Deputy-Conservators and officers of superior rank.

Members of the inferior establishment do not, as a rule, rise higher in the service. A much lower standard of general and technical education is demanded from them than from the members of the superior branch, and they are, therefore, generally unfitted for the higher appointments.

The size of ranges, subdivisions, divisions, or circles, depends on local circumstances, such as the degree of intensiveness of the working, compactness of the forest area, mode of treatment and means of communication. It is, for instance, evident that, other things being equal, a Deputy-Conservator could manage a larger division where there was railway communication than where there was none. It is equally obvious that a Ranger could manage a much larger forest worked by the method of equal areas, and solely with a view to producing firewood-coppice, than a seedling-forest worked by the combined method with a view to the production of large timber and naturally regenerated.

CHAPTER XXVI.

CHOICE OF AN ORGANIZER.

SHOULD the sub-divisional officer who has been in immediate charge of the forest, perhaps for many years, be entrusted with the preparation of a plan, or should a special branch of the executive be employed, whose sole business is to prepare plans of management?

In regard to this question opinions are divided. Of course it is one which can only arise in regard to large tracts of forest belonging to one proprietor—the State, for example. A small proprietor would not be able to keep a special staff fully employed.

It has been urged in favour of the local official's conducting the organization and revision of a forest that he must know the special conditions far better than other people, and that he would take much more interest in the carrying-out of his own programme than that of another.

On the other hand, it has been maintained that the special practical knowledge and skill necessary to organize a forest successfully cannot be acquired in the ordinary routine of an executive officer, who would probably not be called upon to carry out a work of this kind more than a few times during his whole career; that by constant practice a special branch would attain the necessary proficiency; that if the work is done by

a small body of men, it is more likely to be uniformly carried out than by a number of different persons; that the officer in charge is not the proper person to revise his own work; that he will be always there to assist and advise the organizer.

A large majority of countries, including India, have adopted the system of having works of organization carried out by a separate branch of the service; and some have gone still further, and constituted a distinct survey-branch as well as an assessment-branch. As a rule, the separation of these two departments of organization is not desirable. Perhaps it conduces towards efficiency, if a part of the staff is exclusively employed in surveying and the other in assessment, but the work of the two is so intimately connected, that it is expedient they should both be under one head.

The composition of the organization-staff depends on special circumstances. Sometimes a good plan is to have a board of senior officers, presided over by the principal officer. All organization schemes are submitted for the approval of, and have to be passed by, this board, the members of which carry on the work in addition to their ordinary controlling duties. Under the board is the working-staff, which carries out the works of organization, and which is recruited by drafting men into it from the ordinary branch of the service after they have served a few years and become thoroughly acquainted with the working of a sub-division.

This system is only suitable for districts in which the head-quarters of the controlling officers on the board are all in one place. Each member looks spe-

To this must be added the sum of 50 more basal areas to make up the total, 250. Look up, therefore, the number, namely, 57·34, under column headed "14½ inches diameter," and opposite the number 50 of the first column, and add 57·34 to 229·35, the contents already found of 200 stems; the sum is the required result, namely 286·69 square feet.

TABLES

SHOWING THE

AREAS OF CIRCLES FOR DIFFERENT DIAMETERS.

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
0·5	0·001364	**3**·7	0·074667	**6**·8	0·252200	**10**·0	0·545415
6	0·001964	75	0·076699	9	0·259672	1	0·556378
7	0·002673	8	0·078758			2	0·567450
75	0·003068	9	0·082958	**7**·0	0·267253	25	0·573027
8	0·003491			1	0·274944	3	0·578631
9	0·004418	**4**·0	0·087266	2	0·282743	4	0·589921
		1	0·091684	25	0·286684	5	0·601320
1·0	0·005454	2	0·096211	3	0·290652	6	0·612828
1	0·006600	25	0·098516	4	0·298669	7	0·624446
2	0·007854	3	0·100847	5	0·306796	75	0·630295
25	0·008522	4	0·105592	6	0·315032	8	0·636172
3	0·009218	5	0·110447	7	0·323377	9	0·648008
4	0·010690	6	0·115410	75	0·327590		
5	0·012272	7	0·120482	8	0·331830	**11**·0	0·659952
6	0·013963	75	0·123059	9	0·340394	1	0·672006
7	0·015763	8	0·125664			2	0·684169
75	0·016703	9	0·130954	**8**·0	0·349066	25	0·690291
8	0·017671			1	0·357847	3	0·696440
9	0·019690	**5**·0	0·136354	2	0·366737	4	0·708821
		1	0·141862	25	0·371223	5	0·721311
2·0	0·021817	2	0·147480	3	0·375736	6	0·733910
1	0·024053	25	0·150330	4	0·384845	7	0·746619
2	0·026398	3	0·153207	5	0·394062	75	0·753014
25	0·027612	4	0·159043	6	0·403389	8	0·759436
3	0·028853	5	0·164988	7	0·412825	9	0·772362
4	0·031416	6	0·171042	75	0·417583		
5	0·034088	7	0·177205	8	0·422369	**12**·0	0·785398
6	0·036870	75	0·180328	9	0·432023	1	0·798542
7	0·039761	8	0·183478			2	0·811796
75	0·041247	9	0·189859	**9**·0	0·441786	25	0·818463
8	0·042761			1	0·451658	3	0·825158
9	0·045869	**6**·0	0·196349	2	0·461639	4	0·838630
		1	0·202949	25	0·466671	5	0·852211
3·0	0·049087	2	0·209658	3	0·471729	6	0·865901
1	0·052414	25	0·213053	4	0·481929	7	0·879700
2	0·055851	3	0·216475	5	0·492237	75	0·886640
25	0·057610	4	0·223402	6	0·502654	8	0·893608
3	0·059396	5	0·230438	7	0·513181	9	0·907625
4	0·063050	6	0·237583	75	0·518485		
5	0·066813	7	0·244837	8	0·523817	**13**·0	0·92175
6	0·070686	75	0·248505	9	0·534561	1	0·93599

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
13·2	0·95033	**16**·3	1·44911	**19**·5	2·07394	**22**·7	2·81047
25	0·95754	4	1·46695	6	2·09527	75	2·82286
3	0·96479	5	1·48489	7	2·11670	8	2·83529
4	0·97935	6	1·50295	75	2·12746	9	2·86021
5	0·99402	7	1·52111	8	2·13825		
6	1·00880	75	1·53023	9	2·15990	**23**·0	2·88525
7	1·02369	8	1·53938			1	2·91039
75	1·03118	9	1·55776	**20**·0	2·18166	2	2·93564
8	1·03869			1	2·20353	25	2·94831
9	1·05380	**17**·0	1·57625	2	2·22551	3	2·96100
		1	1·59485	25	2·23654	4	2·98647
14·0	1·06901	2	1·61356	3	2·24760	5	3·01205
1	1·08434	25	1·62295	4	2·26980	6	3·03774
2	1·09978	3	1·63237	5	2·29211	7	3·06354
25	1·10753	4	1·65130	6	2·34152	75	3·07648
3	1·11532	5	1·67033	7	2·33705	8	3·08945
4	1·13097	6	1·68948	75	2·34835	9	3·11547
5	1·14674	7	1·70873	8	2·35968		
6	1·16261	75	1·71840	9	2·38243	**24**·0	3·14159
7	1·17859	8	1·72809			1	3·16783
75	1·18662	9	1·74756	**21**·0	2·40528	2	3·19417
8	1·19468			1	2·42824	25	3·20738
9	1·21088	**18**·0	1·76715	2	2·45131	3	3·22062
		1	1·78683	25	2·46289	4	3·24718
15·0	1·22718	2	1·80663	3	2·47449	5	3·27385
1	1·24360	25	1·81657	4	2·49778	6	3·30063
2	1·26013	3	1·82654	5	2·52118	7	3·32752
25	1·26843	4	1·84656	6	2·54469	75	3·34101
3	1·27676	5	1·86668	7	2·56831	8	3·35452
4	1·29351	6	1·88692	75	2·58015	9	3·38163
5	1·31036	7	1·90726	8	2·59203		
6	1·32732	75	1·91748	9	2·61587	**25**·0	3·40884
7	1·34439	8	1·92772			1	3·43617
75	1·35297	9	1·94828	**22**·0	2·63981	2	3·46360
8	1·36157			1	2·66386	25	3·47736
9	1·37886	**19**·0	1·96895	2	2·68802	3	3·49115
		1	1·98973	25	2·70015	4	3·51880
16·0	1·39626	2	2·01062	3	2·71229	5	3·54656
1	1·41377	25	2·02110	4	2·73667	6	3·57443
2	1·43139	3	2·03162	5	2·76116	7	3·60241
25	1·44024	4	2·05272	6	2·78576	75	3·61644

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
25·8	3·63050	**29**·0	4·58694	**32**·2	5·65508	**35**·3	6·79636
9	3·65870	1	4·61863	25	5·67266	4	6·83492
		2	4·65043	3	5·69026	5	6·87359
26·0	3·68701	25	4·66637	4	5·72555	6	6·91237
1	3·71542	3	4·68233	5	5·76095	7	6·95126
2	3·74395	4	4·71435	6	5·79645	75	6·97075
25	3·75825	5	4·74647	7	5·83207	8	6·99026
3	3·77258	6	4·77871	75	5·84992	9	7·02936
4	3·80132	7	4·81105	8	5·86779		
5	3·83018	75	4·82726	9	5·90363	**36**·0	7·06858
6	3·85914	8	4·84350			1	7·10790
7	3·88821	9	4·87607	**33**·0	5·93957	2	7·14734
75	3·90279			1	5·97562	25	7·16709
8	3·91739	**30**·0	4·90874	2	6·01178	3	7·18688
9	3·94668	1	4·94151	25	6·02990	4	7·22653
		2	4·97440	3	6·04805	5	7·26629
27·0	3·97608	25	4·99089	4	6·08443	6	7·30616
1	4·00558	3	5·00740	5	6·12092	7	7·34614
2	4·03520	4	5·04051	6	6·15752	75	7·36617
25	4·05005	5	5·07372	7	6·19422	8	7·38623
3	4·06492	6	5·10705	75	6·21262	9	7·42643
4	4·09476	7	5·14048	8	6·23104		
5	4·12470	75	5·15724	9	6·26796	**37**·0	7·46673
6	4·15475	8	5·17403			1	7·50715
7	4·18492	9	5·20768	**34**·0	6·30500	2	7·54767
75	4·20004			1	6·34214	25	7·56797
8	4·21519	**31**·0	5·24144	2	6·37939	3	7·58830
9	4·24557	1	5·27531	25	6·39806	4	7·62905
		2	5·30929	3	6·41675	5	7·66990
28·0	4·27605	25	5·32632	4	6·45422	6	7·71086
1	4·30665	3	5·34338	5	6·49180	7	7·75193
2	4·33736	4	5·37757	6	6·52949	75	7·77251
25	4·35275	5	5·41188	7	6·56729	8	7·79311
3	4·36817	6	5·44630	75	6·58623	9	7·83440
4	4·39910	7	5·48082	8	6·60519		
5	4·43013	75	5·49812	9	6·64321	**38**·0	7·87579
6	4·46128	8	5·51546			1	7·91730
7	4·49253	9	5·55020	**35**·0	6·68133	2	7·95891
75	4·50820			1	6·71957	25	7·97976
8	4·52389	**32**·0	5·58505	2	6·75791	3	8·00064
9	4·55536	1	5·62001	25	6·77712	4	8·04247

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
38·5	8·08441	**41**·7	9·48417	**44**·8	10·94670	**48**·0	12·56636
6	8·12647	75	9·50693	9	10·99562	1	12·61878
7	8·16863	8	9·52971			2	12·67130
75	8·18975	9	9·57536	**45**·0	11·04465	25	12·69760
8	8·21090			1	11·09380	3	12·72393
9	8·25327	**42**·0	9·62112	2	11·14305	4	12·77667
		1	9·66699	25	11·16771	5	12·82952
39·0	8·29576	2	9·71297	3	11·19224	6	12·88248
1	8·33836	25	9·73600	4	11·24188	7	12·93556
2	8·38107	3	9·75906	5	11·29145	75	12·96213
25	8·40246	4	9·80525	6	11·34114	8	12·98873
3	8·42388	5	9·85156	7	11·39084	9	13·04202
4	8·46680	6	9·89797	75	11·41588		
5	8·50984	7	9·94450	8	11·44084	**49**·0	13·09541
6	8·55298	75	9·96780	9	11·49086	1	13·14892
7	8·59623	8	9·99113			2	13·20253
75	8·61790	9	10·03787	**46**·0	11·54098	25	13·22938
8	8·63959			1	11·59121	3	13·25626
9	8·68306	**43**·0	10·08472	2	11·64156	4	13·31009
		1	10·13168	25	11·66677	5	13·36403
40·0	8·72664	2	10·17875	3	11·69201	6	13·41808
1	8·77033	25	10·20233	4	11·74257	7	13·47224
2	8·81413	3	10·22593	5	11·79324	75	13·49936
25	8·83606	4	10·27322	6	11·84401	8	13·52651
3	8·85803	5	10·32061	7	11·89490	9	13·58089
4	8·90205	6	10·36812	75	11·92039		
5	8·94617	7	10·41574	8	11·94590	**50**·0	13·63537
6	8·99040	75	10·43958	9	11·99700	1	13·68997
7	9·03475	8	10·46346			2	13·74468
75	9·05696	9	10·51129	**47**·0	12·04822	25	13·77207
8	9·07920			1	12·09954	3	13·79949
9	9·12376	**44**·0	10·55923	2	12·15097	4	13·85441
		1	10·60728	25	12·17673	5	13·90945
41·0	9·16843	2	10·65545	3	12·20251	6	13·96459
1	9·21321	25	10·67957	4	12·25417	7	14·01984
2	9·25809	3	10·70371	5	12·30593	75	14·04750
25	9·28058	4	10·75209	6	12·35779	8	14·07520
3	9·30309	5	10·80058	7	12·40977	9	14·13067
4	9·34820	6	10·84918	75	12·43580		
5	9·39341	7	10·89788	8	12·46186	**51**·0	14·18624
6	9·43873	75	10·92228	9	12·51406	1	14·24193

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
51·2	14·29773	**54**·3	16·08151	**57**·5	18·03278	**60**·7	20·09576
25	14·32567	4	16·14079	6	18·09556	75	20·12888
3	14·35363	5	16·19919	7	18·15845	8	20·16203
4	14·40965	6	16·25969	75	18·18993	9	20·22841
5	14·46577	7	16·31931	8	18·22144		
6	14·52200	75	16·34916	9	18·28455	**61**·0	20·29489
7	14·57835	8	16·37903			1	20·36149
75	14·60655	9	16·43886	**58**·0	18·34776	2	20·42819
8	14·63479			1	18·41108	25	20·46158
9	14·69135	**55**·0	16·49880	2	18·47451	3	20·49500
		1	16·55885	25	18·50627	4	20·56193
52·0	14·74802	2	16·61901	3	18·53806	5	20·62896
1	14·80480	25	16·64913	4	18·60170	6	20·69610
2	14·86169	3	16·67928	5	18·66746	7	20·76335
25	14·89017	4	16·73966	6	18·72933	75	20·79701
3	14·91868	5	16·80015	7	18·79331	8	20·83071
4	14·97579	6	16·86074	75	18·82534	9	20·89818
5	15·03298	7	16·92145	8	18·85740		
6	15·09032	75	16·95184	9	18·92159	**62**·0	20·96575
7	15·14776	8	16·98227			1	21·03344
75	15·17651	9	17·04318	**59**·0	18·98590	2	21·10123
8	15·20530			1	19·05031	25	21·13517
9	15·26295	**56**·0	17·10421	2	19·11483	3	21·16914
		1	17·16536	25	19·14713	4	21·23715
53·0	15·32071	2	17·22661	3	19·17946	5	21·30527
1	15·37858	25	17·25727	4	19·24420	6	21·37350
2	15·43655	3	17·28796	5	19·30905	7	21·44185
25	15·46558	4	17·34943	6	19·37401	75	21·47606
3	15·49464	5	17·41101	7	19·43908	8	21·51029
4	15·55284	6	17·47270	75	19·47166	9	21·57885
5	15·61114	7	17·53450	8	19·50426		
6	15·66955	75	17·56543	9	19·56954	**63**·0	21·64752
7	15·72808	8	17·59640			1	21·71630
75	15·75738	9	17·65841	**60**·0	19·63494	2	21·78518
8	15·78671			1	19·70044	25	21·81967
9	15·84545	**57**·0	17·72053	2	19·76606	3	21·85418
		1	17·78277	25	19·79891	4	21·92328
54·0	15·90430	2	17·84511	3	19·83178	5	21·99250
1	15·96326	25	17·87632	4	19·89761	6	22·06182
2	16·02233	3	17·90756	5	19·96355	7	22·13125
25	16·05190	4	17·97012	6	20·02960	75	22·16601

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
63·8	22·20079	**67**·0	24·48368	**70**·2	26·87827	**73**·3	29·30455
9	22·27044	1	24·55682	25	26·91657	4	29·38456
		2	24·63007	3	26·95490	5	29·46468
64·0	22·34020	25	24·66673	4	27·03164	6	29·54491
1	22·41007	3	24·70343	5	27·10849	7	29·62525
2	22·48004	4	24·77689	6	27·18545	75	29·66546
25	22·51507	5	24·85047	7	27·26251	8	29·70570
3	22·55013	6	24·92416	75	27·30109	9	29·78626
4	22·62032	7	24·99795	8	27·33969		
5	22·69063	75	25·03489	9	27·41698	**74**·0	29·86693
6	22·76104	8	25·07185			1	29·94770
7	22·83156	9	25·14587	**71**·0	27·49437	2	30·02859
75	22·86686			1	27·57187	25	30·06907
8	22·90219	**68**·0	25·21999	2	27·64949	3	30·10958
9	22·97293	1	25·29422	25	27·68833	4	30·19068
		2	25·36856	3	27·72721	5	30·27190
65·0	23·04378	25	25·40577	4	27·80504	6	30·35322
1	23·11474	3	25·44301	5	27·88298	7	30·43465
2	23·18581	4	25·51757	6	27·96103	75	30·47540
25	23·22138	5	25·59224	7	28·03919	8	30·51619
3	23·25699	6	25·66701	75	28·07831	9	30·59784
4	23·32827	7	25·74190	8	28·11745		
5	23·39967	75	25·77938	9	28·19583	**75**·0	30·67959
6	23·47117	8	25·81689			1	30·76146
7	23·54278	9	25·89200	**72**·0	28·27431	2	30·84344
75	23·57863			1	28·35290	25	30·88447
8	23·61451	**69**·0	25·96721	2	28·43161	3	30·92552
9	23·68634	1	26·04253	25	28·47100	4	31·00772
		2	26·11796	3	28·51042	5	31·09002
66·0	23·75828	25	26·15572	4	28·58935	6	31·17243
1	23·83033	3	26·19350	5	28·66838	7	31·25495
2	23·90249	4	26·26915	6	28·74752	75	31·29625
25	23·93861	5	26·34491	7	28·82676	8	31·33758
3	23·97475	6	26·42078	75	28·86643	9	31·42032
4	24·04713	7	26·49675	8	28·90612		
5	24·11961	75	26·53478	9	28·98559	**76**·0	31·50317
6	24·19221	8	26·57284			1	31·58613
7	24·26491	9	26·64903	**73**·0	29·06517	2	31·66919
75	24·30131			1	29·14485	25	31·71077
8	24·33773	**70**·0	26·72534	2	29·22464	3	31·75237
9	24·41065	1	26·80175	25	29·26458	4	31·83566

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
76·5	31·91905	**79**·7	34·64525	**82**·8	37·39278	**86**·0	40·33889
6	32·00255	75	34·68873	9	37·48316	1	40·43276
7	32·08616	8	34·73225			2	40·52673
75	32·12801	9	34·81935	**83**·0	37·57364	25	40·57376
8	32·16989			1	37·66423	3	40·62082
9	32·25372	**80**·0	34·90656	2	37·75494	4	40·71501
		1	34·99388	25	37·80033	5	40·80931
77·0	32·33766	2	35·08131	3	37·84575	6	40·90373
1	32·42170	25	35·12507	4	37·93667	7	40·99825
2	32·50586	3	35·16885	5	38·02770	75	41·04555
25	32·54798	4	35·25650	6	38·11884	8	41·09288
3	32·59013	5	35·34426	7	38·21008	9	41·18761
4	32·67450	6	35·43212	75	38·25575		
5	32·75899	7	35·52010	8	38·30144	**87**·0	41 28246
6	32·84358	75	35·56413	9	38·39291	1	41·37742
7	32·92829	8	35·60818			2	41·47248
75	32·97068	9	35·69638	**84**·0	38·48448	25	41·52006
8	33·01310			1	38·57617	3	41·56766
9	33·09802	**81**·0	35·78468	2	38·66796	4	41·66294
		1	35·87309	25	38·71395	5	41·75834
78·0	33·18305	2	35·96161	3	38·75986	6	41·85384
1	33·26819	25	36·00591	4	38·85187	7	41·94945
2	33·35344	3	36·05024	5	38·94399	75	41·99730
25	33·39610	4	36·13898	6	39·03622	8	42·04517
3	33·43879	5	36·22783	7	39·12856	9	42·14100
4	33·52426	6	36·31679	75	39·17477		
5	33·60984	7	36·40585	8	39·22101	**88**·0	42·23694
6	33·69552	75	36·45043	9	39·31357	1	42·33299
7	33·78131	8	36·49503			2	42·42914
75	33·82425	9	36·58431	**85**·0	39·40623	25	42·47726
8	33·86722			1	39·49901	3	42·52541
9	33·95323	**82**·0	36·67370	2	39·59189	4	42·62178
		1	36·76321	25	39·63837	5	42·71827
79·0	34·03935	2	36·85282	3	39·68489	6	42·81486
1	34·12558	25	36·89767	4	39·77799	7	42·91156
2	34·21192	3	36·94254	5	39·87120	75	42·95995
25	34·25513	4	37·03237	6	39·96452	8	43·00837
3	35·29837	5	37·12231	7	40·05795	9	43·10529
4	34·38493	6	37·21236	75	40·10471		
5	34·47159	7	37·30251	8	40·15149	**89**·0	43·20232
6	34·55836	75	37·34763	9	40·24514	1	43·29946

Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.	Diameter.	Area of corresponding circle.
in.	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*	*in.*	*sq. ft.*
89·2	43·39671	**92**·3	46·46549	**95**·5	49·74321	**98**·7	53·13264
25	43·44537	4	46·56622	6	49·84744	75	53·18648
3	43·49406	5	46·66707	7	49·95178	8	53·24036
4	43·59153	6	46·76803	75	50·00400	9	53·34819
5	43·68911	7	46·86909	8	50·05623		
6	43·78679	75	46·91967	9	50·16078	**99**·0	53·45612
7	43·88458	8	46·97027			1	53·56417
75	43·93352	9	47·07155	**96**·0	50·26545	2	53·67233
8	43·98248			1	50·37022	25	53·72645
9	44·08049	**93**·0	47·17294	2	50·47510	3	53·78059
		1	47·27445	25	50·52759	4	53·88897
90·0	44·17861	2	47·37606	3	50·58010	5	53·99745
1	44·27681	25	47·42690	4	50·68520	6	54·10604
2	44·37518	3	47·47778	5	50·79041	7	54·21474
25	44·42439	4	47·57960	6	50·89573	75	54·26913
3	44·47363	5	47·68154	7	51·00116	8	54·32355
4	44·57219	6	47·78359	75	51·05391	9	54·43247
5	44·67085	7	47·88575	8	51·10669		
6	44·76963	75	47·93687	9	51·21234	**100**·0	54·54154
7	44·86851	8	47·98801				
75	44·91799	9	48·09039	**97**·0	51·31810		
8	44·96750			1	51·42396		
9	45·06661	**94**·0	48·19287	2	51·52994		
		1	48·29546	25	51·58296		
91·0	45·16582	2	48·39816	3	51·63602		
1	45·26514	25	48·44956	4	51·74221		
2	45·36457	3	48·50097	5	51·84851		
25	45·41432	4	48·60389	6	51·95492		
3	45·46410	5	48·70692	7	52·06144		
4	45·56375	6	48·81006	75	52·11474		
5	45·66351	7	48·91331	8	52·16807		
6	45·76337	75	48·96497	9	52·27481		
7	45·86335	8	49·01666				
75	45·91338	9	49·12013	**98**·0	52·38166		
8	45·96343			1	52·48861		
9	46·06362	**95**·0	49·22370	2	52·59568		
		1	49·32739	25	52·64925		
92·0	46·16393	2	49·43118	3	52·70285		
1	46·26434	25	49·48312	4	52·81013		
2	46·36486	3	49·53508	5	52·91753		
25	46·41516	4	49·63909	6	53·02503		

TABLES

SHOWING

(1) THE CUBIC CONTENTS OF LOGS AND CYLINDERS OF GIVEN DIAMETER; AND

(2) THE SUM OF THE BASAL AREAS OF STEMS OF THE SAME DIAMETER.

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	2	2½	3	3½	4	4½	5	5½.
	Cubic or Square Feet.							
1	0·02	0·03	0·05	0·07	0·09	0·11	0·14	0·16
2	0·04	0·07	0·10	0·13	0·17	0·22	0·27	0·33
3	0·07	0·10	0·15	0·20	0·26	0·33	0·41	0·49
4	0·09	0·14	0·20	0·27	0·35	0·44	0·55	0·66
5	0·11	0·17	0·25	0·33	0·44	0·55	0·68	0·82
6	0·13	0·20	0·29	0·40	0·52	0·66	0·82	0·99
7	0·15	0·24	0·34	0·47	0·61	0·77	0·95	1·15
8	0·17	0·27	0·39	0·53	0·70	0·88	1·09	1·32
9	0·20	0·31	0·44	0·60	0·79	0·99	1·23	1·48
10	0·22	0·34	0·49	0·67	0·87	1·10	1·36	1·65
11	0·24	0·37	0·54	0·73	0·96	1·21	1·50	1·81
12	0·26	0·41	0·59	0·80	1·05	1·33	1·64	1·98
13	0·28	0·44	0·64	0·87	1·13	1·44	1·77	2·14
14	0·31	0·48	0·69	0·94	1·22	1·55	1·91	2·31
15	0·33	0·51	0·74	1·00	1·31	1·66	2·05	2·47
16	0·35	0·55	0·79	1·07	1·40	1·77	2·18	2·64
17	0·37	0·58	0·83	1·14	1·48	1·88	2·32	2·80
18	0·39	0·61	0·88	1·20	1·57	1·99	2·45	2·97
19	0·41	0·65	0·93	1·27	1·66	2·10	2·59	3·13
20	0·44	0·68	0·98	1·34	1·75	2·21	2·73	3·30
21	0·46	0·72	1·03	1·40	1·83	2·32	2·86	3·46
22	0·48	0·75	1·08	1·47	1·92	2·43	3·00	3·63
23	0·50	0·78	1·13	1·54	2·01	2·54	3·14	3·79
24	0·52	0·82	1·18	1·60	2·09	2·65	3·27	3·96
25	0·55	0·85	1·23	1·67	2·18	2·76	3·41	4·12
26	0·57	0·89	1·28	1·74	2·27	2·87	3·55	4·29
27	0·59	0·92	1·33	1·80	2·36	2·98	3·68	4·45
28	0·61	0·95	1·37	1·87	2·44	3·09	3·82	4·62
29	0·63	0·99	1·42	1·94	2·53	3·20	3·95	4·78
30	0·65	1·02	1·47	2·00	2·62	3·31	4·09	4·95
31	0·68	1·06	1·52	2·07	2·71	3·42	4·23	5·11
32	0·70	1·09	1·57	2·14	2·79	3·53	4·36	5·28
33	0·72	1·12	1·62	2·20	2·88	3·64	4·50	5·44
34	0·74	1·16	1·67	2·27	2·97	3·76	4·64	6·61
35	0·76	1·19	1·72	2·34	3·05	3·87	4·77	5·77

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	2	2½	3	3½	4	4½	5	5½
	CUBIC OR SQUARE FEET.							
36	0·79	1·23	1·77	2·41	3·14	3·98	4·91	5·94
37	0·81	1·26	1·82	2·47	3·23	4·09	5·05	6·10
38	0·83	1·30	1·87	2·54	3·32	4·20	5·18	6·27
39	0·85	1·33	1·91	2·61	3·40	4·31	5·32	6·43
40	0·87	1·36	1·96	2·67	3·49	4·42	5·45	6·60
41	0·89	1·40	2·01	2·74	3·58	4·53	5·59	6·76
42	0·92	1·43	2·06	2·81	3·67	4·64	5·73	6·93
43	0·94	1·47	2·11	2·87	3·75	4·75	5·86	7·09
44	0·96	1·50	2·16	2·94	3·84	4·86	6·00	7·26
45	0·98	1·53	2·21	3·01	3·93	4·97	6·14	7·42
46	1·00	1·57	2·26	3·07	4·01	5·08	6·27	7·59
47	1·03	1·60	2·31	3·14	4·10	5·19	6·41	7·75
48	1·05	1·64	2·36	3·21	4·19	5·30	6·54	7·92
49	1·07	1·67	2·41	3·27	4·28	5·41	6·68	8·08
50	1·09	1·70	2·45	3·34	4·36	5·52	6·82	8·25
51	1·11	1·74	2·50	3·41	4·45	5·63	6·95	8·41
52	1·13	1·77	2·55	3·47	4·54	5·74	7·09	8·58
53	1·16	1·81	2·60	3·54	4·63	5·85	7·23	8·74
54	1·18	1·84	2·65	3·61	4·71	5·96	7·36	8·91
55	1·20	1·87	2·70	3·67	4·80	6·07	7·50	9·07
56	1·22	1·91	2·75	3·74	4·89	6·18	7·64	9·24
57	1·24	1·94	2·80	3·81	4·97	6·30	7·77	9·40
58	1·27	1·98	2·85	3·88	5·06	6·41	7·91	9·57
59	1·29	2·01	2·90	3·94	5·15	6·52	8·04	9·73
60	1·31	2·05	2·95	4·01	5·24	6·63	8·18	9·90
61	1·33	2·08	2·99	4·08	5·32	6·74	8·32	10·06
62	1·35	2·11	3·04	4·14	5·41	6·85	8·45	10·23
63	1·37	2·15	3·09	4·21	5·50	6·96	8·59	10·39
64	1·40	2·18	3·14	4·28	5·59	7·07	8·73	10·56
65	1·42	2·22	3·19	4·34	5·67	7·18	8·86	10·72
66	1·44	2·25	3·24	4·41	5·76	7·29	9·00	10·89
67	1·46	2·28	3·29	4·48	5·85	7·40	9·14	11·05
68	1·48	2·32	3·34	4·54	5·93	7·51	9·27	11·22
69	1·51	2·35	3·39	4·61	6·02	7·62	9·41	11·38
70	1·53	2·39	3·44	4·68	6·11	7·73	9·54	11·55

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	6	6¼	7	7½	8	8½	9	9½
	CUBIC OR SQUARE FEET.							
36	7·07	8·30	9·62	11·04	12·57	14·19	15·90	17·72
37	7·26	8·53	9·89	11·35	12·92	14·58	16·35	18·21
38	7·46	8·76	10·16	11·66	13·26	14·97	16·79	18·71
39	7·66	8·99	10·42	11·97	13·61	15·37	17·23	19·20
40	7·85	9·22	10·69	12·27	13·96	15·76	17·67	19·69
41	8·05	9·45	10·96	12·58	14·31	16·16	18·11	20·18
42	8·25	9·68	11·22	12·89	14·66	16·55	18·56	20·67
43	8·44	9·91	11·49	13·19	15·01	16·94	19·00	21·17
44	8·64	10·14	11·76	13·50	15·36	17·34	19·44	21·66
45	8·84	10·37	12·03	13·81	15·71	17·73	19·88	22·15
46	9·03	10·60	12·29	14·11	16·06	18·13	20·32	22·64
47	9·23	10·83	12·56	14·42	16·41	18·52	20·76	23·14
48	9·42	11·06	12·83	14·73	16·76	18·91	21·21	23·63
49	9·62	11·29	13·10	15·03	17·10	19·31	21·65	24·12
50	9·82	11·52	13·36	15·34	17·45	19·70	22·09	24·61
51	10·01	11·75	13·63	15·65	17·80	20·10	22·53	25·10
52	10·21	11·98	13·90	15·95	18·15	20·49	22·97	25·60
53	10·41	12·21	14·16	16·26	18·50	20·89	23·41	26·09
54	10·60	12·44	14·43	16·57	18·85	21·28	23·86	26·58
55	10·80	12·67	14·70	16·87	19·20	21·67	24·30	27·07
56	11·00	12·90	14·97	17·18	19·55	22·07	24·74	27·57
57	11·19	13·13	15·23	17·49	19·90	22·46	25·18	28·06
58	11·39	13·37	15·50	17·79	20·25	22·86	25·62	28·55
59	11·58	13·60	15·77	18·10	20·60	23·25	26·07	29·04
60	11·78	13·83	16·04	18·41	20·94	23·64	26·51	29·53
61	11·98	14·06	16·30	18·71	21·29	24·04	26·95	30·03
62	12·17	14·29	16·57	19·02	21·64	24·43	27·39	30·52
63	12·37	14·52	16·84	19·33	21·99	24·83	27·83	31·01
64	12·57	14·75	17·10	19·64	22·34	25·22	28·27	31·50
65	12·76	14·98	17·37	19·94	22·69	25·61	28·72	32·00
66	12·96	15·21	17·64	20·25	23·04	26·01	29·16	32·49
67	13·16	15·44	17·91	20·56	23·39	26·40	29·60	32·98
68	13·35	15·67	18·17	20·86	23·74	26·80	30·04	33·47
69	13·55	15·90	18·44	21·17	24·09	27·19	30·48	33·96
70	13·74	16·13	18·71	21·48	24·43	27·58	30·93	34·46

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	6	6½	7	7½	8	8½	9	9½
	CUBIC OR SQUARE FEET.							
71	13·94	16·36	18·97	21·78	24·78	27·98	31·37	34·95
72	14·14	16·59	19·24	22·09	25·13	28·37	31·81	35·44
73	14·33	16·82	19·51	22·40	25·48	28·77	32·25	35·93
74	14·53	17·05	19·78	22·70	25·83	29·16	32·69	36·43
75	14·73	17·28	20·04	23·01	26·18	29·55	33·13	36·92
76	14·92	17·51	20·31	23·32	26·53	29·95	33·58	37·41
77	15·12	17·74	20·58	23·62	26·88	30·34	34·02	37·90
78	15·32	17·97	20·85	23·93	27·23	30·74	34·46	38·39
79	15·51	18·20	21·11	24·24	27·58	31·13	34·90	38·89
80	15·71	18·44	21·38	24·54	27·93	31·52	35·34	39·38
81	15·90	18·67	21·65	24·85	28·27	31·92	35·78	39·87
82	16·10	18·90	21·91	25·16	28·62	32·31	36·23	40·36
83	16·30	19·13	22·18	25·46	28·97	32·71	36·67	40·86
84	16·49	19·36	22·45	25·77	29·32	33·10	37·11	41·35
85	16·69	19·59	22·72	26·08	29·67	33·50	37·55	41·84
86	16·89	19·82	22·98	26·38	30·02	33·89	37·99	42·33
87	17·08	20·05	23·25	26·69	30·37	34·28	38·44	42·82
88	17·28	20·28	23·52	27·00	30·72	34·68	38·88	43·32
89	17·48	20·51	23·79	27·30	31·07	35·07	39·32	43·81
90	17·67	20·74	24·05	27·61	31·42	35·47	39·76	44·30
91	17·87	20·97	24·32	27·92	31·76	35·86	40·20	44·79
92	18·06	21·20	24·59	28·23	32·11	36·25	40·64	45·29
93	18·26	21·43	24·85	28·53	32·46	36·65	41·09	45·78
94	18·46	21·66	25·12	28·84	32·81	37·04	41·53	46·27
95	18·65	21·89	25·39	29·15	33·16	37·44	41·97	46·76
96	18·85	22·12	25·66	29·45	33·51	37·83	42·41	47·26
97	19·05	22·35	25·92	29·76	33·86	38·22	42·85	47·75
98	19·24	22·58	26·19	30·07	34·21	38·62	43·30	48·24
99	19·44	22·81	26·46	30·37	34·56	39·01	43·74	48·73
100	19·64	23·04	26·73	30·68	34·91	39·41	44·18	49·22
200	39·27	46·09	53·45	61·36	69·81	78·81	88·36	98·45
300	58·90	69·13	80·18	92·04	104·72	118·22	132·54	147·67
400	78·54	92·18	106·90	122·72	139·63	157·62	176·72	196·90
500	98·17	115·22	133·63	153·40	174·53	197·03	220·90	246·12
600	117·81	138·26	160·35	184·08	209·44	236·44	265·07	295·34
700	137·44	161·31	187·08	214·76	244·35	275·84	309·25	344·57
800	157·08	184·35	213·80	245·44	279·25	315·25	353·43	393·79
900	176·71	207·39	240·53	276·12	314·16	354·65	397·61	443·02
1000	196·35	230·44	267·25	306·80	349·07	394·06	441·79	492·24

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	10	10½	11	11½	12	12½	13	13½
	Cubic or Square Feet.							
1	0·55	0·60	0·66	0·72	0·79	0·85	0·92	0·99
2	1·09	1·20	1·32	1·44	1·57	1·70	1·84	1·99
3	1·64	1·80	1·98	2·16	2·36	2·56	2·77	2·98
4	2 18	2·41	2·64	2·89	3·14	3·41	3·69	3·98
5	2·73	3·01	3·30	3·61	3·93	4·26	4·61	4·97
6	3·27	3·61	3·96	4·33	4·71	5·11	5·53	5·96
7	3·82	4·21	4·62	5·05	5·50	5·97	6·45	6·96
8	4·36	4·81	5·28	5·77	6·28	6·82	7·37	7·95
9	4·91	5·41	5·94	6·49	7·07	7·67	8·30	8·95
10	5·45	6·01	6·60	7·21	7·85	8·52	9·22	9·94
11	6·00	6·61	7·26	7·93	8·64	9·37	10·14	10·93
12	6·55	7·22	7·92	8·66	9·42	10·23	11·06	11·93
13	7·09	7·82	8·58	9·38	10·21	11·08	11·98	12·92
14	7·64	8·42	9·24	10·10	11·00	11·93	12·90	13·92
15	8·18	9·02	9·90	10·82	11·78	12·78	13·83	14·91
16	8·73	9·62	10·56	11·54	12·57	13·64	14·75	15·90
17	9·27	10·22	11·22	12·26	13·35	14 49	15·67	16·90
18	9·82	10·82	11·88	12·98	14·14	15·34	16·59	17·89
19	10·36	11·43	12·54	13·70	14·92	16·19	17·51	18·89
20	10·91	12·03	13·20	14·43	15·71	17·04	18·44	19·88
21	11·45	12·63	13·86	15·15	16·49	17·90	19·36	20·87
22	12·00	13·23	14·52	15·87	17·28	18·75	20·28	21·87
23	12·54	13·83	15·18	16·59	18·06	19·60	21·20	22·86
24	13·09	14·43	15·84	17·31	18·85	20·45	22·12	23·86
25	13·64	15·03	16·50	18·03	19·64	21·31	23·04	24·85
26	14·18	15·63	17·16	18·75	20·42	22·16	23·97	25·84
27	14·73	16·24	17·82	19·48	21·21	23·01	24·89	26·84
28	15·27	16·84	18·48	20·20	21·99	23·86	25·81	27·83
29	15·82	17·44	19·14	20·92	22·78	24·71	26·73	28·83
30	16·36	18·04	19·80	21·64	23·56	25·57	27·65	29·82
31	16·91	18·64	20·46	22·36	24·35	26·42	28·57	30·81
32	17·45	19·24	21·12	23·08	25·13	27·27	29·50	31·81
33	18·00	19·84	21·78	23·80	25·92	28·12	30·42	32·80
34	18·54	20·44	22·44	24·52	26·70	28·98	31·34	33·80
35	19·09	21·05	23·10	25·25	27·49	29·83	32·26	34·79

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	10	10½	11	11½	12	12½	13	13½
	CUBIC OR SQUARE FEET.							
36	19·64	21·65	23·76	25·97	28·27	30·68	33·18	35·78
37	20·18	22·25	24·42	26·69	29·06	31·53	34·10	36·78
38	20·73	22·85	25·08	27·41	29·85	32·38	35·03	37·77
39	21·27	23·45	25·74	28·13	30·63	33·24	35·95	38·77
40	21·82	24·05	26·40	28·85	31·42	34·09	36·87	39·76
41	22·36	24·65	27·06	29·57	32·20	34·94	37·79	40·75
42	22·91	25·26	27·72	30·30	32·99	35·79	38·71	41·75
43	23·45	25·86	28·38	31·02	33·77	36·65	39·64	42·74
44	24·00	26·46	29·04	31·74	34·56	37·50	40·56	43·74
45	24·54	27·06	29·70	32·46	35·34	38·35	41·48	44·73
46	25·09	27·66	30·36	33·18	36·13	39·20	42·40	45·72
47	25·63	28·26	31·02	33·90	36·91	40·05	43·32	46·72
48	26·18	28·86	31·68	34·62	37·70	40·91	44·24	47·71
49	26·73	29·46	32·34	35·34	38·48	41·76	45·17	48·71
50	27·27	30·07	33·00	36·07	39·27	42·61	46·09	49·70
51	27·82	30·67	33·66	36·79	40·06	43·46	47·01	50·70
52	28·36	31·27	34·32	37·51	40·84	44·31	47·93	51·69
53	28·91	31·87	34·98	38·23	41·63	45·17	48·85	52·68
54	29·45	32·47	35·64	38·95	42·41	46·02	49·77	53·68
55	30·00	33·07	36·30	39·67	43·20	46·87	50·70	54·67
56	30·54	33·67	36·96	40·39	43·98	47·72	51·62	55·67
57	31·08	34·28	37·62	41·11	44·77	48·58	52·54	56·66
58	31·63	34·88	38·28	41·84	45·55	49·43	53·46	57·65
59	32·18	35·48	38·94	42·56	46·34	50·28	54·38	58·65
60	32·73	36·08	39·60	43·28	47·12	51·13	55·31	59·64
61	33·27	36·68	40·26	44·00	47·91	51·98	56·23	60·64
62	33·82	37·28	40·92	44·72	48·69	52·84	57·15	61·63
63	34·36	37·88	41·58	45·44	49·48	53·69	58·07	62·62
64	34·91	38·48	42·24	46·16	50·27	54·54	58·99	63·62
65	35·45	39·09	42·90	46·89	51·05	55·39	59·91	64·61
66	36·00	39·69	43·56	47·61	51·84	56·25	60·84	65·61
67	36·54	40·29	44·22	48·33	52·62	57·10	61·76	66·60
68	37·09	40·89	44·88	49·05	53·41	57·95	62·68	67·59
69	37·63	41·49	45·54	49·77	54·19	58·80	63·60	68·59
70	38·18	42·09	46·20	50·49	54·98	59·65	64·52	69·58

Length (feet) or number of Stems	DIAMETER IN INCHES.							
	10	10½	11	11½	12	12½	13	13½
	CUBIC OR SQUARE FEET.							
71	38·72	42·69	46·86	51·21	55·76	60·51	65·44	70·58
72	39·27	43·30	47·52	51·93	56·55	61·36	66·37	71·57
73	39·82	43·90	48·18	52·66	57·33	62·21	67·29	72·56
74	40·36	44·50	48·84	53·38	58·12	63·06	68·21	73·56
75	40·91	45·10	49·50	54·10	58·91	63·92	69·13	74·55
76	41·45	45·70	50·16	54·82	59·69	64·77	70·05	75·55
77	42·00	46·30	50·82	55·54	60·48	65·62	70·97	76·54
78	42·54	46·90	51·48	56·26	61·26	66·47	71·90	77·53
79	43·09	47·50	52·14	56·98	62·05	67·32	72·82	78·53
80	43·63	48·11	52·80	57·70	62·83	68·18	73·74	79·52
81	44·18	48·71	53·46	58·43	63·62	69·03	74·66	80·52
82	44·72	49·31	54·12	59·15	64·40	69·88	75·58	81·51
83	45·27	49·91	54·78	59·87	65·19	70·73	76·51	82·50
84	45·82	50·51	55·44	60·59	65·97	71·59	77·43	83·50
85	46·36	51·11	56·10	61·31	66·76	72·44	78·35	84·49
86	46·91	51·71	56·76	62·03	67·54	73·29	79·27	85·49
87	47·45	52·31	57·42	62·75	68·33	74·14	80·19	86·48
88	48·00	52·92	58·08	63·48	69·12	74·99	81·11	87·47
89	48·54	53·52	58·74	64·20	69·90	75·85	82·04	88·47
90	49·09	54·12	59·40	64·92	70·69	76·70	82·96	89·46
91	49·63	54·72	60·06	65·63	71·47	77·55	83·88	90·46
92	50·18	55·32	60·72	66·36	72·26	78·40	84·80	91·45
93	50·72	55·92	61·38	67·08	73·04	79·26	85·72	92·44
94	51·27	56·52	62·04	67·80	73·83	80·11	86·64	93·44
95	51·81	57·13	62·70	68·52	74·61	80·96	87·57	94·43
96	52·36	57·73	63·36	69·25	75·40	81·81	88·49	95·43
97	52·91	58·33	64·02	69·97	76·18	82·66	89·41	96·42
98	53·45	58·93	64·68	70·69	76·97	83·52	90·33	97·41
99	54·00	59·53	65·34	71·41	77·75	84·37	91·25	98·41
100	54·54	60·13	66·00	72·13	78·54	85·22	92·18	99·40
200	109·08	120·26	131·99	144·26	157·08	170·44	184·36	198·80
300	163·63	180·40	197·99	216·39	235·62	255·66	276·53	298·21
400	218·17	240·53	263·98	288·52	314·16	340·88	368·70	397·61
500	272·71	300·66	329·98	360·66	392·70	426·11	460·88	497·01
600	827·25	360·79	395·97	432·79	471·24	511·33	553·05	596·41
700	381·79	420·92	461·97	504·92	549·78	596·55	645·23	695·81
800	436·34	481·06	527·96	577·05	628·32	681·77	737·40	795·22
900	490·88	541·19	593·96	649·18	706·86	766·99	829·58	894·62
1000	545·42	601·32	659·95	721·31	785·40	852·21	921·75	994·02

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	14	14½	15	15½	16	16½	17	17½
	CUBIC OR SQUARE FEET.							
1	1·07	1·15	1·23	1·31	1·40	1·48	1·58	1·67
2	2·14	2·29	2·45	2·62	2·79	2·97	3·15	3·34
3	3·21	3·44	3·68	3·93	4·19	4·45	4·73	5·01
4	4·28	4·59	4·91	5·24	5·59	5·94	6·31	6·68
5	5·35	5·73	6·14	6·55	6·98	7·42	7·88	8·35
6	6·41	6·88	7·36	7·86	8·38	8·91	9·46	10·02
7	7·48	8·03	8·59	9·17	9·77	10·39	11·03	11·69
8	8·55	9·17	9·82	10·48	11·17	11·88	12·61	13·36
9	9·62	10·32	11·04	11·79	12·57	13·36	14·19	15·03
10	10·69	11·47	12·27	13·10	13·96	14·85	15·76	16·70
11	11·76	12·61	13·50	14·41	15·36	16·33	17·34	18·37
12	12·83	13·76	14·73	15·72	16·76	17·82	18·92	20·04
13	13·90	14·91	15·95	17·03	18·15	19·30	20·49	21·71
14	14·97	16·05	17·18	18·35	19·55	20·79	22·07	23·38
15	16·04	17·20	18·41	19·66	20·94	22·27	23·64	25·05
16	17·10	18·35	19·63	20·97	22·34	23·76	25·22	26·73
17	18·17	19·49	20·86	22·28	23·74	25·24	26·80	28·40
18	19·24	20·64	22·09	23·59	25·13	26·73	28·37	30·07
19	20·31	21·79	23·32	24·90	26·53	28·21	29·95	31·74
20	21·38	22·93	24·54	26·21	27·93	29·70	31·53	33·41
21	22·45	24·08	25·77	27·52	29·32	31·18	33·10	35·08
22	23·52	25·23	27·00	28·83	30·72	32·67	34·68	36·75
23	24·59	26·38	28·23	30·14	32·11	34·15	36·25	38·42
24	25·66	27·52	29·45	31·45	33·51	35·64	37·83	40·09
25	26·73	28·67	30·68	32·76	34·91	37·12	39·41	41·76
26	27·79	29·82	31·91	34·07	36·30	38·61	40·98	43·43
27	28·86	30·96	33·13	35·38	37·70	40·09	42·56	45·10
28	29·93	32·11	34·36	36·69	39·10	41·58	44·14	46·77
29	31·00	33·25	35·59	38·00	40·49	43·06	45·71	48·44
30	32·07	34·40	36·82	39·31	41·89	44·55	47·29	50·11
31	33·14	35·55	38·04	40·62	43·28	46·03	48·86	51·78
32	34·21	36·70	39·27	41·93	44·68	47·52	50·44	53·45
33	35·28	37·84	40·50	43·24	46·08	49·00	52·02	55·12
34	36·35	38·99	41·72	44·55	47·47	50·49	53·59	56·79
35	37·42	40·14	42·95	45·86	48·87	51·97	55·17	58·46

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	14	14½	15	15½	16	16½	17	17½.
	CUBIC OR SQUARE FEET.							
36	38·48	41·28	44·18	47·17	50·27	53·46	56·75	60·13
37	39 55	42·43	45·41	48·48	51·66	54·94	58·32	61·80
38	40 62	43·58	46·63	49·79	53·06	56·43	59·90	63·47
39	41·69	44·72	47·86	51·10	54·45	57·91	61·47	65·14
40	42·76	45·87	49·09	52·41	55·85	59·40	63·05	66·81
41	43·83	47·02	50·31	53·72	57·25	60·88	64·63	68·48
42	44·90	48·16	51·54	55·04	58 64	62·37	66·20	70·15
43	45·97	49·31	52·77	56 35	60 04	63 85	67·78	71·82
44	47·04	50·46	54·00	57·66	61·44	65·34	69·36	73·49
45	48·11	51·60	55·22	58·97	62·83	66·82	70·93	75·16
46	49·17	52·75	56·45	60·28	64·23	68·30	72·51	76·84
47	50·24	53·90	57·68	61 59	65 62	69·79	74·08	78·51
48	51·31	55·04	58·90	62 90	67·02	71·27	75·66	80·18
49	52·38	56·19	60·13	64·21	68·42	72·76	77·24	81·85
50	53·45	57·34	61·36	65 52	69·81	74·24	78·81	83·52
51	54·52	58·48	62·59	66·83	71·21	75·73	80·39	85·19
52	55·59	59·63	63·81	68·14	72·61	77·21	81·97	86·86
53	56·66	60·78	65·04	69·45	74·00	78·70	83·54	88·53
54	57·73	61·92	66·27	70·76	75·40	80·18	85·12	90·20
55	58·80	63·07	67·49	72·07	76·79	81·67	86·69	91·87
56	59·86	64·22	68·72	73·38	78·19	83·15	88·27	93·54
57	60·93	65·36	69·95	74·69	79·59	84·64	89·85	95·21
58	62·00	66 51	71 18	76·00	80·98	86·12	91·42	96·88
59	63·07	67·66	72·40	77·31	82·38	87·61	93·00	98·55
60	64·14	68·80	73·63	78·62	83·78	89·09	94·58	100·22
61	65·21	69·95	74·86	79·93	85·17	90·58	96·15	101·89
62	66·28	71·10	76 09	81·24	86·57	92 06	97·73	103·56
63	67·35	72 24	77·31	82·55	87·96	93 55	99·30	105·23
64	68·42	73·39	78·54	83 86	89 36	95 03	100·88	106·90
65	69·49	74·54	79·77	85·17	90·76	96·52	102·46	108·57
66	70·55	75·68	80 99	86·48	92·15	98·00	104·03	110·24
67	71·62	76·83	82·22	87 79	93·55	99 49	105·61	111·91
68	72·69	77·98	83 45	89 10	94·95	100·97	107·19	113·58
69	73 76	79·12	84·68	90·41	96·34	102·46	108·76	115·25
70	74·83	80·27	85·90	91·73	97·74	103·94	110·34	116·92

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	14	14½	15	15½	16	16½	17	17½
	CUBIC OR SQUARE FEET.							
71	75·90	81·42	87·13	93·04	99·13	105·43	111·91	118·59
72	76·97	82·57	88·36	94·35	100·53	106·91	113·49	120·26
73	78·04	83·71	89·58	95·66	101·93	108·40	115·07	121·93
74	79·11	84·86	90·81	96·97	103·32	109·88	116·64	123·60
75	80·18	86·01	92·04	98·28	104·72	111·37	118·22	125·27
76	81·24	87·15	93·27	99·59	106·12	112·85	119·80	126·95
77	82·31	88·30	94·49	100·90	107·51	114·34	121·37	128·62
78	83·38	89·45	95·72	102·21	108·91	115·82	122·95	130·29
79	84·45	90·59	96·95	103·52	110·30	117·31	124·52	131·96
80	85·52	91·74	98·17	104·83	111·70	118·79	126·10	133·63
81	86·59	92·89	99·40	106·14	113·10	120·28	127·68	135·30
82	87·66	94·03	100·63	107·45	114·49	121·76	129·25	136·97
83	88·73	95·18	101·86	108·76	115·89	123·25	130·83	138·64
84	89·80	96·33	103·08	110·07	117·29	124·73	132·41	140·31
85	90·87	97·47	104·31	111·38	118·68	126·22	133·98	141·98
86	91·93	98·62	105·54	112·69	120·08	127·70	135·56	143·65
87	93·00	99·77	106·76	114·00	121·47	129·19	137·13	145·32
88	94·07	100·91	107·99	115·31	122·87	130·67	138·71	146·99
89	95·14	102·06	109·22	116·62	124·27	132·16	140·29	148·66
90	96·21	103·21	110·45	117·93	125·66	133·64	141·86	150·33
91	97·28	104·35	111·67	119·24	127·06	135·12	143·44	152·00
92	98·35	105·50	112·90	120·55	128·46	136·61	145·02	153·67
93	99·42	106·65	114·13	121·86	129·85	138·09	146·59	155·34
94	100·49	107·79	115·35	123·17	131·25	139·58	148·17	157·01
95	101·56	108·94	116·58	124·48	132·64	141·06	149·74	158·68
96	102·62	110·09	117·81	125·79	134·04	142·55	151·32	160·35
97	103·69	111·23	119·04	127·10	135·44	144·03	152·90	162·02
98	104·76	112·38	120·26	128·42	136·83	145·52	154·47	163·69
99	105·83	113·53	121·49	129·73	138·23	147·00	156·05	165·36
100	106·90	114·67	122·72	131·04	139·63	148·49	157·63	167·03
200	213·80	229·35	245·44	262·07	279·25	296·98	315·25	334·07
300	320·70	344·02	368·15	393·11	418·88	445·47	472·88	501·10
400	427·60	458·70	490·87	524·14	558·50	593·96	630·50	668·13
500	534·51	573·37	613·59	655·18	698·13	742·45	788·13	835·17
600	641·41	688·04	736·31	786·22	837·76	890·93	945·75	1002·20
700	748·31	802·72	859·03	917·25	977·38	1039·42	1103·38	1169·23
800	855·21	917·39	981·74	1048·29	1117·01	1187·91	1261·00	1336·26
900	962·11	1032·07	1104·46	1179·32	1256·63	1336·40	1418·63	1503·30
1000	1069·01	1146·74	1227·18	1310·36	1396·26	1484·89	1576·25	1670·33

Length (feet) or number of Stems.	DIAMETER IN INCHES							
	18	18½	19	19½	20	20½	21	21½
	CUBIC OR SQUARE FEET.							
1	1·77	1·87	1·97	2·07	2·18	2·29	2·41	2·52
2	3·53	3·73	3·94	4·15	4·36	4·58	4·81	5·04
3	5·30	5·60	5·91	6·22	6·54	6·88	7·22	7·56
4	7·07	7·47	7·88	8·30	8·73	9·17	9·62	10·08
5	8·84	9·33	9·84	10·37	10·91	11·46	12·03	12·61
6	10·60	11·20	11·81	12·44	13·09	13·75	14·43	15·13
7	12·37	13·07	13·78	14·52	15·27	16·04	16·84	17·65
8	14·14	14·93	15·75	16·59	17·45	18·34	19·24	20·17
9	15·90	16·80	17·72	18·66	19·63	20·63	21·65	22·69
10	17·67	18·67	19·69	20·74	21·82	22·92	24·05	25·21
11	19·44	20·53	21·66	22·81	24·00	25·21	26·46	27·73
12	21·21	22·40	23·63	24·89	26·18	27·51	28·86	30·25
13	22·97	24·27	25·60	26·96	28·36	29·80	31·27	32·78
14	24·74	26·13	27·57	29·04	30·54	32·09	33·67	35·30
15	26·51	28·00	29·53	31·11	32·72	34·38	36·08	37·82
16	28·27	29·87	31·50	33·18	34·91	36·67	38·48	40·34
17	30·04	31·73	33·47	35·26	37·09	38·97	40·89	42·86
18	31·81	33·60	35·44	37·33	39·27	41·26	43·30	45·38
19	33·58	35·47	37·41	39·40	41·45	43·55	45·70	47·90
20	35·34	37·33	39·38	41·48	43·63	45·84	48·11	50·42
21	37·11	39·20	41·35	43·55	45·82	48·13	50·51	52·94
22	38·88	41·07	43·32	45·63	48·00	50·43	52·92	55·47
23	40·64	42·93	45·29	47·70	50·18	52·72	55·32	57·99
24	42·41	44·80	47·25	49·77	52·36	55·01	57·73	60·51
25	44·18	46·67	49·22	51·85	54·54	57·30	60·13	63·03
26	45·95	48·53	51·19	53·92	56·72	59·59	62·54	65·55
27	47·71	50·40	53·16	56·00	58·90	61·89	64·94	68·07
28	49·48	52·27	55·13	58·07	61·09	64·18	67·35	70·59
29	51·25	54·13	57·10	60·14	63·27	66·47	69·75	73·11
30	53·01	56·00	59·07	62·22	65·45	68·76	72·16	75·64
31	54·78	57·87	61·04	64·29	67·63	71·06	74·56	78·16
32	56·55	59·73	63·01	66·37	69·81	73·35	76·97	80·68
33	58·32	61·60	64·98	68·44	71·99	75·64	79·37	83·20
34	60·08	63·47	66·94	70·51	74·18	77·93	81·78	85·72
35	61·85	65·33	68·91	72·59	76·36	80·22	84·18	88·24

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	18	18½	19	19½	20	20½	21	21½
	CUBIC OR SQUARE FEET.							
36	63·62	67·20	70·88	74·66	78·54	82·52	86·59	90·76
37	65·38	69·07	72·85	76·74	80·72	84·81	89·00	93·28
38	67·15	70·93	74·82	78·81	82·90	87·10	91·40	95·80
39	68·92	72·80	76·79	80·88	85·08	89·39	93·81	98·33
40	70·69	74·67	78·76	82·96	87·27	91·68	96·21	100·85
41	72·45	76·53	80·73	85·03	89·45	93·98	98·62	103·37
42	74·22	78·40	82·70	87·11	91·63	96·27	101·02	105·89
43	75·99	80·27	84·66	89·18	93·81	98·56	103·43	108·41
44	77·75	82·13	86·63	91·25	95·99	100·85	105·83	110·93
45	79·52	84·00	88·60	93·33	98·17	103·14	108·24	113·45
46	81·29	85·87	90·57	95·40	100·36	105·44	110·64	115·97
47	83·06	87·73	92·54	97·47	102·54	107·73	113·05	118·50
48	84·82	89·60	94·51	99·55	104·72	110·02	115·45	121·02
49	86·59	91·47	96·48	101·62	106·90	112·31	117·86	123·54
50	88·36	93·33	98·45	103·70	109·08	114·61	120·26	126·06
51	90·12	95·20	100·42	105·77	111·26	116·90	122·67	128·58
52	91·89	97·07	102·39	107·84	113·45	119·19	125·07	131·10
53	93·66	98·93	104·35	109·92	115·63	121·48	127·48	133·62
54	95·43	100·80	106·32	111·99	117·81	123·77	129·89	136·14
55	97·19	102·67	108·29	114·07	119·99	126·07	132·29	138·66
56	98·96	104·53	110·26	116·14	122·17	128·36	134·70	141·19
57	100·73	106·40	112·23	118·21	124·35	130·65	137·10	143·71
58	102·49	108·27	114·20	120·29	126·54	132·94	139·51	146·23
59	104·26	110·13	116·17	122·36	128·72	135·23	141·91	148·75
60	106·03	112·00	118·14	124·44	130·90	137·53	144·32	151·27
61	107·80	113·87	120·11	126·51	133·08	139·82	146·72	153·79
62	109·56	115·73	122·07	128·58	135·26	142·11	149·13	156·31
63	111·33	117·60	124·04	130·66	137·44	144·40	151·53	158·83
64	113·10	119·47	126·01	132·73	139·63	146·70	153·94	161·36
65	114·86	121·33	127·98	134·81	141·81	148·99	156·34	163·88
66	116·63	123·20	129·95	136·88	143·99	151·28	158·75	166·40
67	118·40	125·07	131·92	138·95	146·17	153·57	161·15	168·92
68	120·17	126·93	133·89	141·03	148·35	155·86	163·56	171·44
69	121·93	128·80	135·86	143·10	150·53	158·16	165·96	173·96
70	123·70	130·67	137·83	145·18	152·72	160·45	168·37	176·48

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	18	18½	19	19½	20	20½	21	21½
	Cubic or Square Feet.							
71	125·47	132·53	139·80	147·25	154·90	162·74	170·77	179·00
72	127·23	134·40	141·76	149·32	157·08	165·03	173·18	181·52
73	129·00	136·27	143·73	151·40	159·26	167·32	175·59	184·05
74	130·77	138·13	145·70	153·47	161·44	169·62	177·99	186·57
75	132·54	140·00	147·67	155·55	163·62	171·91	180·40	189·09
76	134·30	141·87	149·64	157·62	165·81	174·20	182·80	191·61
77	136·07	143·73	151·61	159·69	167·99	176·49	185·21	194·13
78	137·84	145·60	153·58	161·77	170·17	178·78	187·61	196·65
79	139·60	147·47	155·55	163·84	172·35	181·08	190·02	199·17
80	141·37	149·33	157·52	165·92	174·53	183·37	192·42	201·69
81	143·14	151·20	159·48	167·99	176·71	185·66	194·83	204·22
82	144·91	153·07	161·45	170·06	178·90	187·95	197·23	206·74
83	146·67	154·93	163·42	172·14	181·08	190·25	199·64	209·26
84	148·44	156·80	165·39	174·21	183·26	192·54	202·04	211·78
85	150·21	158·67	167·36	176·28	185·44	194·83	204·45	214·30
86	151·97	160·53	169·33	178·36	187·62	197·12	206·85	216·82
87	153·74	162·40	171·30	180·43	189·80	199·41	209·26	219·34
88	155·51	164·27	173·27	182·51	191·99	201·71	211·66	221·86
89	157·28	166·13	175·24	184·58	194·17	204·00	214·07	224·39
90	159·04	168·00	177·21	186·65	196·35	206·29	216·48	226·91
91	160·81	169·87	179·17	188·73	198·53	208·58	218·88	229·43
92	162·58	171·73	181·14	190·80	200·71	210·87	221·29	231·95
93	164·34	173·60	183·11	192·88	202·89	213·17	223·69	234·47
94	166·11	175·47	185·08	194·95	205·08	215·46	226·10	236·99
95	167·88	177·33	187·05	197·02	207·26	217·75	228·50	239·51
96	169·65	179·20	189·02	199·10	209·44	220·04	230·91	242·03
97	171·41	181·07	190·99	201·17	211·62	222·33	233·31	244·55
98	173·18	182·93	192·96	203·25	213·80	224·63	235·72	247·08
99	174·95	184·80	194·93	205·32	215·98	226·92	238·12	249·60
100	176·72	186·67	196·90	207·39	218·17	229·21	240·53	252·12
200	353·43	373·34	393·79	414·79	436·33	458·42	481·06	504·24
300	530·15	560·00	590·69	622·18	654·50	687·63	721·58	756·35
400	706·86	746·67	787·58	829·58	872·66	916·84	962·11	1008·47
500	883·58	933·34	984·48	1036·97	1090·83	1146·06	1202·64	1260·59
600	1060·29	1120·01	1181·37	1244·36	1309·00	1375·27	1443·17	1512·71
700	1237·01	1306·68	1378·27	1451·76	1527·16	1604·48	1683·70	1764·83
800	1413·72	1493·34	1575·16	1659·15	1745·33	1833·69	1924·22	2016·94
900	1590·44	1680·01	1772·06	1866·55	1963·49	2062·90	2164·75	2269·06
1000	1767·15	1866·68	1968·95	2078·94	2181·66	2292·11	2405·28	2521·18

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	22	22½	23	23½	24	24½	25	25½
	Cubic or Square Feet.							
1	2·64	2·76	2·89	3·01	3·14	3·27	3·41	3·55
2	5·28	5·52	5·77	6·02	6·28	6·55	6·82	7·09
3	7·92	8·28	8·66	9·04	9·42	9·82	10·23	10·64
4	10·56	11·04	11·54	12·05	12·57	13·10	13·64	14·19
5	13·20	13·81	14·43	15·06	15·71	16·37	17·04	17·73
6	15·84	16·57	17·31	18·07	18·85	19·64	20·45	21·28
7	18·48	19·33	20·20	21·08	21·99	22·92	23·86	24·83
8	21·12	22·09	23·08	24·10	25·13	26·19	27·27	28·37
9	23·76	24·85	25·97	27·11	28·27	29·46	30·68	31·92
10	26·40	27·61	28·85	30·12	31·42	32·74	34·09	35·47
11	29·04	30·37	31·74	33·13	34·56	36·01	37·50	39·01
12	31·68	33·13	34·62	36·14	37·70	39·29	40·91	42·56
13	34·32	35·90	37·51	39·16	40·84	42·56	44·31	46·11
14	36·96	38·66	40·39	42·17	43·98	45·83	47·72	49·65
15	39·60	41·42	43·28	45·18	47·12	49·11	51·13	53·20
16	42·24	44·18	46·16	48·19	50·27	52·38	54·54	56·74
17	44·88	46·94	49·05	51·20	53·41	55·66	57·95	60·29
18	47·52	49·70	51·93	54·22	56·55	58·93	61·36	63·84
19	50·16	52·46	54·82	57·23	59·69	62·20	64·77	67·38
20	52·80	55·22	57·71	60·24	62·83	65·48	68·18	70·93
21	55·44	57·98	60·59	63·25	65·97	68·75	71·59	74·48
22	58·08	60·75	63·48	66·27	69·11	72·02	74·99	78·02
23	60·72	63·51	66·36	69·28	72·26	75·30	78·40	81·57
24	63·36	66·27	69·25	72·29	75·40	78·57	81·81	85·12
25	66·00	69·03	72·13	75·30	78·54	81·85	85·22	88·66
26	68·64	71·79	75·02	78·31	81·68	85·12	88·63	92·21
27	71·27	74·55	77·90	81·33	84·82	88·39	92·04	95·76
28	73·91	77·31	80·79	84·34	87·96	91·67	95·45	99·30
29	76·55	80·07	83·67	87·35	91·11	94·94	98·86	102·85
30	79·19	82·83	86·56	90·36	94·25	98·22	102·27	106·40
31	81·83	85·60	89·44	93·37	97·39	101·49	105·67	109·94
32	84·47	88·36	92·33	96·39	100·53	104·76	109·08	113·49
33	87·11	91·12	95·21	99·40	103·67	108·04	112·49	117·04
34	89·75	93·88	98·10	102·41	106·81	111·31	115·90	120·58
35	92·39	96·64	100·98	105·42	109·96	114·58	119·31	124·13

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	22	22½	23	23½	24	24½	25	25½
	CUBIC OR SQUARE FEET.							
36	95·03	99·40	103·87	108·43	113·10	117·86	122·72	127·68
37	97·67	102·16	106·75	111·45	116·24	121·13	126·13	131·22
38	100·31	104·92	109·64	114·46	119·38	124·41	129·54	134·77
39	102·95	107·69	112·52	117·47	122·52	127·68	132·94	138·32
40	105·59	110·45	115·41	120·48	125·66	130·95	136·35	141·86
41	108·23	113·21	118·30	123·49	128·81	134·23	139·76	145·41
42	110·87	115·97	121·18	126·51	131·95	137·50	143·17	148·96
43	113·51	118·73	124·07	129·52	135·09	140·78	146·58	152·50
44	116·15	121·49	126·95	132·53	138·23	144·05	149 99	156·05
45	118·79	124·25	129·84	135·54	141·37	147·32	153·40	159·60
46	121·43	127·01	132·72	138·55	144·51	150·60	156·81	163·14
47	124·07	129·77	135·61	141·57	147·65	153·87	160·22	166·69
48	126·71	132·51	138·49	144·58	150·80	157·14	163·62	170·23
49	129·35	135·30	141·38	147·59	153·94	160·42	167·03	173·78
50	131·99	138·06	144 26	150·60	157·08	163·69	170·44	177·33
51	134·63	140·82	147·15	153·61	160·22	166·97	173·85	180·87
52	137·27	143·58	150·03	156·63	163·36	170·24	177·26	184·42
53	139·91	146·34	152·92	159·64	166·50	173·51	180·67	187·97
54	142·55	149·10	155·80	162·65	169·65	176·79	184·08	191·51
55	145·19	151·86	158·69	165·66	172·79	180·06	187·49	195·06
56	147·83	154·62	161·57	168·67	175·93	183·34	190·90	198·61
57	150·47	157·39	164·46	171·69	179·07	186·61	194·30	201·15
58	153·11	160·15	167·34	174·70	182·21	189·88	197·71	205·70
59	155·75	162·91	170·23	177·71	185·35	193·16	201·12	209·25
60	158·39	165·67	173·12	180·72	188·50	196·43	204·53	212·79
61	161·03	168·43	176·00	183·74	191·64	199·70	207·94	216·34
62	163·67	171·19	178·89	186·75	194·78	202·98	211·35	219·89
63	166·31	173·95	181·77	189·76	197·92	206·25	214·76	223·43
64	168·95	176·71	184·66	192·77	201·06	209·53	218·17	226·98
65	171·59	179·48	187·54	195·78	204·20	212·80	221·57	230·53
66	174·23	182·24	190·43	198·80	207·34	216·07	224·98	234·07
67	176·87	185·00	193·31	201·81	210·49	219·35	228·39	237·62
68	179·51	187·76	196·20	204·82	213·63	222·62	231 80	241·17
69	182·15	190·52	199·08	207·83	216·77	225·90	235·21	244·71
70	184·79	193·28	201·97	210·84	219·91	229·17	238·62	248·26

Length (feet) or number of Stems.	DIAMETER IN INCHES.							
	22	22½	23	23½	24	24½	25	25½
	Cubic or Square Feet.							
71	187·43	196·04	204·85	213·86	223·05	232·44	242·03	251·81
72	190·07	198·80	207·74	216·87	226·19	235·72	245·44	255·35
73	192·71	201·56	210·62	219·88	229·34	238·99	248·85	258·90
74	195·35	204·33	213·51	222·89	232·48	242·26	252·25	262·45
75	197·99	207·09	216·39	225·90	235·62	245·54	255·66	265·99
76	200·63	209·85	219·28	228·92	238·76	248·81	259·07	269·54
77	203·27	212·61	222·16	231·93	241·90	252·09	262·48	273·09
78	205·91	215·37	225·05	234·94	245·04	255·36	265·89	276·63
79	208·54	218·13	227·93	237·95	248·19	258·63	269·30	280·18
80	211·18	220·89	230·82	240·96	251·33	261·91	272·71	283·72
81	213·82	223·56	233·71	243·98	254·47	265·18	276·12	287·27
82	216·46	226·42	236·59	246·99	257·61	268·46	279·52	290·82
83	219·10	229·18	239·48	250·00	260·75	271·73	282·93	294·36
84	221·74	231·94	242·36	253·01	263·89	275·00	286·34	297·91
85	224·38	234·70	245·25	256·02	267·04	278·28	289·75	301·46
86	227·02	237·46	248·13	259·04	270·18	281·55	293·16	305·00
87	229·66	240·22	251·02	262·05	273·32	284·82	296·57	308·55
88	232·30	242·98	253·90	265·06	276·46	288·10	299·98	312·10
89	234·94	245·74	256·79	268·07	279·60	291·37	303·39	315·64
90	237·58	248·50	259·67	271·08	282·74	294·65	306·80	319·19
91	240·22	251·27	262·56	274·10	285·88	297·92	310·20	322·74
92	242·86	254·03	265·44	277·11	289·03	301·19	313·61	326·28
93	245·50	256·79	268·33	280·12	292·17	304·47	317·02	329·83
94	248·14	259·55	271·21	283·13	295·31	307·74	320·43	333·38
95	250·78	262·31	274·10	286·14	298·45	311·02	323·84	336·92
96	253·42	265·07	276·98	289·16	301·59	314·29	327·25	340·47
97	256·06	267·83	279·87	292·17	304·73	317·56	330·66	344·02
98	258·70	270·59	282·75	295·18	307·88	320·84	334·07	347·56
99	261·34	273·35	285·64	298·19	311·02	324·11	337·48	351·11
100	263·98	276·12	288·53	301·21	314·16	327·39	340·88	354·66
200	527·96	552·23	577·05	602·41	628·32	654·77	681·77	709·31
300	791·94	828·35	865·58	903·62	942·18	982·16	1022·65	1063·97
400	1055·92	1104·46	1154·10	1204·82	1256·64	1309·54	1363·54	1418·62
500	1319·91	1380·58	1442·63	1506·03	1570·80	1636·93	1704·42	1773·28
600	1583·89	1656·70	1731·15	1807·23	1884·95	1964·31	2045·30	2127·94
700	1847·87	1932·81	2019·68	2108·44	2199·11	2291·70	2386·19	2482·59
800	2111·85	2208·93	2308·20	2409·64	2513·27	2619·08	2727·07	2837·25
900	2375·83	2485·04	2596·73	2710·85	2827·43	2946·47	3067·96	3191·90
1000	2639·81	2761·16	2885·25	3012·05	3141·59	3273·85	3408·84	3540·56

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	26	26½	27	27½	28	28½
	CUBIC OR SQUARE FEET					
1	3·69	3·83	3·98	4·12	4·28	4·43
2	7·37	7·66	7·95	8·25	8·55	8·86
3	11·06	11·49	11·93	12·37	12·83	13·29
4	14·75	15·32	15·90	16·50	17·10	17·72
5	18·44	19·15	19·88	20·62	21·38	22·15
6	22·12	22·98	23·86	24·75	25·66	26·58
7	25·81	26·81	27·83	28·87	29·93	31·01
8	29·50	30·64	31·81	33·00	34·21	35·44
9	33·18	34·47	35·78	37·12	38·48	39·87
10	36·87	38·30	39·76	41·25	42·76	44·30
11	40·56	42·13	43·74	45·37	47·04	48·73
12	44·24	45·96	47·71	49·50	51·31	53·16
13	47·93	49·79	51·69	53·62	55·59	57·59
14	51·62	53·62	55·67	57·75	59·86	62·02
15	55·31	57·45	59·64	61·87	64·14	66·45
16	58·99	61·28	63·62	66·00	68·42	70·88
17	62·68	65·11	67·59	70·12	72·69	75·31
18	66·37	68·94	71·57	74·24	76·97	79·74
19	70·05	72·77	75·55	78·37	81·24	84·17
20	73·74	76·60	79·52	82·49	85·52	88·60
21	77·43	80·43	83·50	86·62	89·80	93·03
22	81·11	84·26	87·47	90·74	94·07	97·46
23	84·80	88·09	91·45	94·87	98·35	101·89
24	88·49	91·92	95·43	98·99	102·63	106·32
25	92·18	95·75	99·40	103·12	106·90	110·75
26	95·86	99·58	103·38	107·24	111·18	115·18
27	99·55	103·41	107·35	111·37	115·45	119·61
28	103·24	107·25	111·33	115·49	119·73	124·04
29	106·92	111·08	115·31	119·62	124·01	128·47
30	110·61	114·91	119·28	123·74	128·28	132·90
31	114·30	118·74	123·26	127·87	132·56	137·33
32	117·98	122·57	127·23	131·99	136·83	141·76
33	121·67	126·40	131·21	136·12	141·11	146·19
34	125·36	130·23	135·19	140·24	145·39	150·62
35	129·05	134·06	139·16	144·36	149·66	155·05

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	26	26½	27	27½	28	28½
	CUBIC OR SQUARE FEET.					
36	132·73	137·89	143·14	148·49	153·94	159·48
37	136·42	141·72	147·11	152·61	158·21	163·91
38	140·11	145·55	151·09	156·74	162·49	168·34
39	143·79	149·38	155·07	160·86	166·77	172·78
40	147·48	153·21	159·04	164·99	171·04	177·21
41	151·17	157·04	163·02	169·11	175·32	181·64
42	154·85	160·87	167·00	173·24	179·59	186·07
43	158·54	164·70	170·97	177·36	183·87	190·50
44	162·23	168·53	174·95	181·49	188·15	194·93
45	165·92	172·36	178·92	185·61	192·42	199·36
46	169·60	176·19	182·90	189·74	196·70	203·79
47	173·29	180·02	186·88	193·86	200·97	208·22
48	176·98	183·85	190·85	197·99	205·25	212·65
49	180·66	187·68	194·83	202·11	209·53	217·08
50	184·35	191·51	198·80	206·24	213·80	221·51
51	188·04	195·34	202·78	210·36	218·08	225·94
52	191·72	199·17	206·76	214·48	222·35	230·37
53	195·41	203·00	210·73	218·61	226·63	234·80
54	199·10	206·83	214·71	222·73	230·91	239·23
55	202·79	210·66	216·68	226·86	235·18	243·66
56	206·47	214·49	222·66	230·98	239·46	248·09
57	210·16	218·32	226·64	235·11	243·73	252·52
58	213·85	222·15	230·61	239·23	248·01	256·95
59	217·53	225·98	234·59	243·36	252·29	261·38
60	221·22	229·81	238·56	247·48	256·56	265·81
61	224·91	233·64	242·54	251·61	260·84	270·24
62	228·59	237·47	246·52	255·73	265·12	274·67
63	232·28	241·30	250·49	259·86	269·39	279·10
64	235·97	245·13	254·47	263·98	273·67	283·53
65	239·66	248·96	258·45	268·11	277·94	287·96
66	243·34	252·79	262·42	272·23	282·22	292·39
67	247·03	256·62	266·40	276·35	286·50	296·82
68	250·72	260·45	270·37	280·48	290·77	301·25
69	254·40	264·28	274·35	284·60	295·05	305·68
70	258·09	268·11	278·33	288·73	299·32	310·11

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	26	26½	27	27½	28	28½
	CUBIC OR SQUARE FEET.					
71	261·78	271·94	282·30	292·85	303·60	314·54
72	265·46	275·77	286·28	296·98	307·88	318·97
73	269·15	279·60	290·25	301·10	312·15	323·40
74	272·84	283·43	294·23	305·23	316·42	327·83
75	276·53	287·26	298·21	309·35	320·70	332·26
76	280·21	291·09	302·18	313·48	324·98	336·69
77	283·90	294·92	306·16	317·60	329·26	341·12
78	287·59	298·75	310·13	321·73	333·53	345·55
79	291·27	302·58	314·11	325·85	337·81	349·98
80	294·96	306·41	318·09	329·98	342·08	354·41
81	298·65	310·24	322·06	334·10	346·36	358·84
82	302·33	314·07	326·04	338·23	350·64	363·27
83	306·02	317·90	330·01	342·35	354·91	367·70
84	309·71	321·74	333·99	346·47	359·19	372·13
85	313·40	325·57	337·97	350·60	363·46	376·56
86	317·08	329·40	341·94	354·72	367·74	380·99
87	320·77	333·23	345·91	358·85	372·02	385·42
88	324·46	337·06	349·90	362·97	376·29	389·85
89	328·14	340·89	353·87	367·10	380·57	394·28
90	331·83	344·72	357·85	371·22	384·84	398·71
91	335·52	348·55	361·82	375·35	389·12	403·14
92	339·20	352·38	365·80	379·47	393·40	407·57
93	342·89	356·21	369·78	383·60	397·67	412·00
94	346·58	360·04	373·75	387·72	401·95	416·43
95	350·27	363·87	377·73	391·85	406·22	420·86
96	353·95	367·70	381·70	395·97	410·50	425·29
97	357·64	371·53	385·68	400·10	414·78	429·72
98	361·32	375·36	389·66	404·22	419·05	434·15
99	365·01	379·19	393·63	408·35	423·33	438·58
100	368·70	383·02	397·61	412·47	427·61	443·01
200	737·40	766·04	795·22	824·94	855·21	886·03
300	1106·10	1149·05	1192·82	1237·41	1282·82	1329·04
400	1474·80	1532·07	1590·43	1649·88	1710·42	1772·05
500	1843·51	1915·09	1988·04	2062·35	2138·03	2215·07
600	2212·21	2298·11	2385·65	2474·82	2565·63	2658·08
700	2580·91	2681·13	2783·26	2887·29	2993·24	3101·09
800	2949·61	3064·14	3180·86	3299·76	3420·84	3544·10
900	3318·31	3447·16	3578·47	3712·23	3848·45	3987·12
1000	3687·01	3830·18	3976·08	4124·70	4276·05	4430·13

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	29	29½	30	30½	31	31½
	Cubic or Square Feet.					
1	4·59	4·75	4·91	5·07	5·24	5·41
2	9·17	9·49	9·82	10·15	10·48	10·82
3	13·76	14·24	14·73	15·22	15·72	16·24
4	18·35	18·99	19·63	20·29	20·97	21·65
5	22·93	23·73	24·54	25·37	26·21	27·06
6	27·52	28·48	29·45	30·44	31·45	32·47
7	32·11	33·23	34·36	35·52	36·69	37·88
8	36·70	37·97	39·27	40·59	41·93	43·30
9	41·28	42·72	44·18	45·66	47·17	48·71
10	45·87	47·46	49·09	50·74	52·41	54·12
11	50·46	52·21	54·00	55·81	57·66	59·53
12	55·04	56·96	58·90	60·88	62·90	64·94
13	59·63	61·70	63·81	65·96	68·14	70·35
14	64·22	66·45	68·72	71·03	73·38	75·77
15	68·80	71·20	73·63	76·11	78·62	81·18
16	73·39	75·94	78·54	81·18	83·86	86·59
17	77·98	80·69	83·45	86·25	89·10	92·00
18	82·56	85·44	88·36	91·33	94·35	97·41
19	87·15	90·18	93·27	96·40	99·59	102·83
20	91·74	94·93	98·17	101·47	104·83	108·24
21	96·33	99·68	103·08	106·55	110·07	113·65
22	100·91	104·42	107·99	111·62	115·31	119·06
23	105·50	109·17	112·90	116·70	120·55	124·47
24	110·09	113·92	117·81	121·77	125·79	129·89
25	114·67	118·66	122·72	126·84	131·04	135·30
26	119·26	123·41	127·63	131·92	136·28	140·71
27	123·85	128·15	132·54	136·99	141·52	146·12
28	128·43	132·90	137·44	142·06	146·76	151·53
29	133·02	137·65	142·35	147·14	152·00	156·94
30	137·61	142·39	147·26	152·21	157·24	162·36
31	142·20	147·14	152·17	157·29	162·48	167·77
32	146·78	151·89	157·08	162·36	167·73	173·18
33	151·37	156·63	161·99	167·43	172·97	178·59
34	155·96	161·38	166·90	172·51	178·21	184·00
35	160·54	166·13	171·81	177·58	183·45	189·42

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	29	29½	30	30½	31	31½
	CUBIC OR SQUARE FEET.					
36	165·13	170·87	176·71	182·65	188·69	194·83
37	169·72	175·62	181·62	187·73	193·93	200·24
38	174·30	180·37	186·53	192·80	199·17	205·65
39	178·89	185·11	191·44	197·88	204·42	211·06
40	183·48	189·86	196·35	202·95	209·66	216·48
41	188·06	194·61	201·26	208·02	214·90	221·89
42	192·65	199·35	206·17	213·10	220·14	227·30
43	197·24	204·10	211·08	218·17	225·38	232·71
44	201·83	208·84	215·98	223·24	230·62	238·12
45	206·41	213·59	220·89	228·32	235·86	243·53
46	211·00	218·34	225·80	233·39	241·11	248·95
47	215·59	223·08	230·71	238·46	246·35	254·36
48	220·17	227·83	235·62	243·54	251·59	259·77
49	224·76	232·58	240·53	248·61	256·83	265·18
50	229·35	237·32	245·44	253·69	262·07	270·59
51	233·93	242·07	250·35	258·76	267·31	276·01
52	238·52	246·82	255·25	263·83	272·55	281·42
53	243·11	251·56	260·16	268·91	277·80	286·83
54	247·69	256·31	265·07	273·98	283·04	292·24
55	252·28	261·06	269·98	279·05	288·28	297·65
56	256·87	265·80	274·89	284·13	293·52	303·07
57	261·46	270·55	279·80	289·20	298·76	308·48
58	266·04	275·30	284·71	294·28	304·00	313·89
59	270·63	280·04	289·62	299·35	309·24	319·30
60	275·22	284·79	294·52	304·42	314·49	324·71
61	279·80	289·53	299·43	309·50	319·73	330·12
62	284·39	294·28	304·34	314·57	324·97	335·54
63	288·98	299·03	309·25	319·64	330·21	340·95
64	293·56	303·77	314·16	324·72	335·45	346·36
65	298·15	308·52	319·07	329·79	340·69	351·77
66	302·74	313·27	323·98	334·87	345·93	357·18
67	307·32	318·01	328·89	339·94	351·18	362·60
68	311·91	322·76	333·79	345·01	356·42	368·01
69	316·50	327·51	338·70	350·09	361·66	373·42
70	321·09	332·25	343·61	355·16	366·90	378·83

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	29	29½	30	30½	31	31½
	Cubic or Square Feet.					
71	325·67	337·00	348·52	360·23	372·14	384·24
72	330·26	341·75	353·43	365·31	377·38	389·66
73	334·85	346·49	358·34	370 38	382·62	395·07
74	339·43	351·24	363·25	375·46	387·87	400·48
75	344·02	355·99	368·16	380·53	393·11	405·89
76	348·61	360·73	373·06	385·60	398·35	411·30
77	353·19	365·48	377·97	390·68	403·59	416·71
78	357·78	370·22	382·88	395·75	408·83	422·13
79	362·37	374·97	387·79	400·82	414·07	427·54
80	366·96	379·72	392·70	405·90	419·31	432·95
81	371·54	384·46	397·61	410·97	424·56	438·36
82	376·13	389·21	402·52	416·05	429·80	443·77
83	380·72	393·96	407·43	421·12	435·04	449·19
84	385·30	398·70	412·33	426·19	440·28	454·60
85	389·89	403·45	417·24	431·27	445·52	460·01
86	394·48	408·20	422·15	436·34	450·76	465·42
87	399·06	412·94	427·06	441·41	456·01	470·83
88	403·65	417·69	431·97	446·49	461·25	476·25
89	408·24	422·44	436·88	451·56	466·49	481·66
90	412·82	427·18	441·79	456·64	471·73	487·07
91	417·41	431·93	446·70	461·71	476·97	492·48
92	422·00	436·68	451·60	466·78	482·21	497·89
93	426·59	441·42	456·51	471·86	487·45	503·30
94	431·17	446·17	461·42	476·93	492·70	508·72
95	435·76	450·92	466·33	482·00	497·94	514·13
96	440·35	455·66	471·24	487·08	503·18	519·54
97	444·93	460·41	476·15	492·15	508·42	524·95
98	449·52	465·15	481·06	497·22	513·66	530·36
99	454·11	469·90	485·96	502·30	518·90	535·78
100	458·69	474·65	490·87	507·37	524·14	541·19
200	917·39	949·29	981·75	1014·74	1048·29	1082·38
300	1376·08	1423·94	1472·62	1522·12	1572·43	1623·56
400	1834·78	1898·59	1963·49	2029·49	2096·58	2164·75
500	2293·47	2373·24	2454·37	2536·86	2620·72	2705·94
600	2752·16	2847·88	2945·24	3044·23	3144·86	3247·13
700	3210·86	3322·53	3436·11	3551·61	3669·01	3788·32
800	3669·55	3797·18	3926·99	4058·98	4193·14	4329·50
900	4128·25	4271·83	4417·86	4566·35	4717·29	4870·69
1000	4586·94	4746·47	4908·74	5073·72	5241·44	5411·88

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	32	32½	33	33½	34	34½
	CUBIC OR SQUARE FEET.					
1	5·59	5·76	5·94	6·12	6·30	6·49
2	11·17	11·52	11·88	12·24	12·61	12·98
3	16·76	17·28	17·82	18·36	18·92	19·48
4	22·34	23·04	23·76	24·48	25·22	25·97
5	27·93	28·80	29·70	30·60	31·53	32·46
6	33·51	34·57	35·64	36·73	37·83	38·95
7	39·10	40·33	41·58	42·85	44·14	45·44
8	44·68	46·09	47·52	48·97	50·44	51·93
9	50·27	51·85	53·46	55·09	56·75	58·43
10	55·85	57·61	59·40	61·21	63·05	64·92
11	61·44	63·37	65·34	67·33	69·36	71·41
12	67·02	69·13	71·27	73·45	75·66	77·90
13	72·61	74·89	77·21	79·57	81·97	84·39
14	78·19	80·65	83·15	85·69	88·27	90·89
15	83·78	86·41	89·09	91·81	94·58	97·38
16	89·36	92·18	95·03	97·93	100·88	103·87
17	94·95	97·94	100·97	104·06	107·18	110·36
18	100·53	103·70	106·91	110·18	113·49	116·85
19	106·12	109·46	112·85	116·30	119·80	123·34
20	111·70	115·22	118·79	122·42	126·10	129·84
21	117·29	120·98	124·73	128·54	132·41	136·33
22	122·87	126·74	130·67	134·66	138·71	142·82
23	128·46	132·50	136·61	140·78	145·02	149·31
24	134·04	138·26	142·55	146·90	151·32	155·80
25	139·63	144·02	148·49	153·02	157·63	162·30
26	145·21	149·78	154·43	159·14	163·93	168·79
27	150·80	155·55	160·37	165·26	170·24	175·28
28	156·38	161·31	166·31	171·39	176·54	181·77
29	161·97	167·07	172·25	177·51	182·85	188·26
30	167·55	172·83	178·19	183·63	189·15	194·75
31	173·14	178·59	184·13	189·75	195·45	201·25
32	178·72	184·35	190·07	195·87	201·76	207·74
33	184·31	190·11	196·01	201·99	208·06	214·23
34	189·89	195·87	201·95	208·11	214·37	220·72
35	195·48	201·63	207·88	214·23	220·68	227·21

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	32	32½	33	33½	34	34½
	Cubic or Square Feet.					
36	201·06	207·39	213·82	220·35	226·98	233·70
37	206·65	213·16	219·76	226·47	233·28	240·20
38	212·23	218·92	225·70	232·60	239·59	246·69
39	217·82	224·68	231·64	238·72	245·89	253·18
40	223·40	230·44	237·58	244·84	252·20	259·67
41	228·99	236·20	243·52	250·96	258·50	266·16
42	234·57	241·96	249·46	257·08	264·81	272·66
43	240·16	247·72	255·40	263·20	271·11	279·15
44	245·74	253·48	261·34	269·32	277·42	285·64
45	251·33	259·24	267·28	275·44	283·72	292·13
46	256·91	265·00	273·22	281·56	290·03	298·62
47	262·50	270·76	279·16	287·68	296·33	305·11
48	268·08	276·53	285·10	293·80	302·64	311·61
49	273·67	282·29	291·04	299·93	308·94	318·10
50	279·25	288·05	296·98	306·05	315·25	324·59
51	284·84	293·81	302·92	312·17	321·55	331·08
52	290·42	299·57	308·86	318·29	327·86	337·57
53	296·01	305·33	314·80	324·41	334·16	344·07
54	301·59	311·09	320·74	330·53	340·47	350·56
55	307·18	316·85	326·68	336·65	346·77	357·05
56	312·76	322·61	332·62	342·77	353·08	363·54
57	318·35	328·37	338·56	348·89	359·38	370·03
58	323·93	334·15	344·50	355·01	365·69	376·52
59	329·52	339·90	350·43	361·13	371·99	383·02
60	335·10	345·66	356·37	367·26	378·30	389·51
65	363·03	374·46	386·07	397·86	409·82	421·97
70	390·95	403·27	415·77	428·46	441·35	454·43
75	418·88	432·07	445·47	459·07	472·87	486·89
80	446·80	460·88	475·17	489·67	504·40	519·34
85	474·73	489·68	504·86	520·28	535·92	551·80
90	502·65	518·49	534·56	550·88	567·45	584·26
95	530·58	547·29	564·26	581·49	598·97	616·72
100	558·51	576·09	593·96	612·09	630·50	649·18

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	35	35½	36	36½	37	37½
	CUBIC OR SQUARE FEET.					
1	6·68	6·87	7·07	7·27	7·47	7·67
2	13·36	13·75	14·14	14·53	14·93	15·34
3	20·04	20·62	21·21	21·80	22·40	23·01
4	26·73	27·49	28·27	29·07	29·87	30·68
5	33·41	34·37	35·34	36·33	37·33	38·35
6	40·09	41·24	42·41	43·60	44·80	46·02
7	46·77	48·12	49·48	50·86	52·27	53·69
8	53·45	54·99	56·55	58·13	59·73	61·36
9	60·13	61·86	63·62	65·40	67·20	69·03
10	66·81	68·74	70·69	72·66	74·67	76·70
11	73·49	75·61	77·75	79·93	82·13	84·37
12	80·18	82·48	84·82	87·20	89·60	92·04
13	86·86	89·36	91·89	94·46	97·07	99·71
14	93·54	96·23	98·96	101·73	104·53	107·38
15	100·22	103·10	106·03	108·99	112·00	115·05
16	106·90	109·98	113·10	116·26	119·47	122·72
17	113·58	116·85	120·17	123·53	126·93	130·39
18	120·26	123·72	127·23	130·79	134·40	138·06
19	126·95	130·60	134·30	138·06	141·87	145·73
20	133·63	137·47	141·37	145·33	149·33	153·40
21	140·31	144·35	148·44	152·59	156·80	161·07
22	146·99	151·22	155·51	159·86	164·27	168·74
23	153·67	158·09	162·58	167·12	171·73	176·41
24	160·35	164·97	169·65	174·39	179·20	184·08
25	167·03	171·84	176·71	181·66	186·67	191·75
26	173·71	178·71	183·78	188·92	194·13	199·42
27	180·40	185·59	190·85	196·19	201·60	207·09
28	187·08	192·46	197·92	203·46	209·07	214·76
29	193·76	199·33	204·99	210·72	216·54	222·43
30	200·44	206·21	212·06	217·99	224·00	230·10
31	207·12	213·08	219·13	225·25	231·47	237·77
32	213·80	219·95	226·19	232·52	238·94	245·44
33	220·48	226·83	233·26	239·79	246·40	253·11
34	227·17	233·70	240·33	247·05	253·87	260·78
35	233·85	240·58	247·40	254·32	261·34	268·45

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	35	35½	36	36½	37	37½
	CUBIC OR SQUARE FEET.					
36	240·53	247·45	254·47	261·59	268·80	276·12
37	247·21	254·32	261·54	268·85	276·27	283·79
38	253·89	261·20	268·61	276·12	283·74	291·46
39	260·57	268·07	275·67	283·39	291·20	299·13
40	267·25	274·94	282·74	290·65	298·67	306·80
41	273·93	281·82	289·81	297·92	306·14	314·47
42	280·62	288·69	296·88	305·18	313·60	322·14
43	287·30	295·56	303·95	312·45	321·07	329·81
44	293·98	302·44	311·02	319·72	328·54	337·48
45	300·66	309·31	318·09	326·98	336·00	345·15
46	307·34	316·19	325·15	334·25	343·47	352·82
47	314·02	323·06	332·22	341·52	350·94	360·49
48	320·70	329·93	339·29	348·78	358·40	368·16
49	327·39	336·81	346·36	356·05	365·87	375·83
50	334·07	343·68	353·43	363·31	373·34	383·50
51	340·75	350·55	360·50	370·58	380·80	391·16
52	347·43	357·43	367·57	377·85	388·27	398·83
53	354·11	364·30	374·63	385·11	395·74	406·50
54	360·79	371·17	381·70	392·38	403·20	414·17
55	367·47	378·05	388·77	399·65	410·67	421·84
56	374·15	384·92	395·84	406·91	418·14	429·51
57	380·84	391·79	402·91	414·18	425·60	437·18
58	387·52	398·67	409·98	421·44	433·07	444·85
59	394·20	405·54	417·05	428·71	440·54	452·52
60	400·88	412·42	424·11	435·98	448·00	460·19
65	434·29	446·78	459·46	472·31	485·34	498·54
70	467·69	481·15	494·80	508·64	522·67	536·89
75	501·10	515·52	530·14	544·97	560·00	575·24
80	534·51	549·89	565·49	581·30	597·34	613·59
85	567·91	584·26	600·83	617·63	634·67	651·94
90	601·32	618·62	636·17	653·97	672·01	690·29
95	634·73	652·99	671·51	690·30	709·34	728·64
100	668·13	687·36	706·86	726·63	746·67	766·99

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	35	35½	36	36½	37	37½
	CUBIC OR SQUARE FEET.					
1	6·68	6·87	7·07	7·27	7·47	7·67
2	13·36	13·75	14·14	14·53	14·93	15·34
3	20·04	20·62	21·21	21·80	22·40	23·01
4	26·73	27·49	28·27	29·07	29·87	30·68
5	33·41	34·37	35·34	36·33	37·33	38·35
6	40·09	41·24	42·41	43·60	44·80	46·02
7	46·77	48·12	49·48	50·86	52·27	53·69
8	53·45	54·99	56·55	58·13	59·73	61·36
9	60·13	61·86	63·62	65·40	67·20	69·03
10	66·81	68·74	70·69	72·66	74·67	76·70
11	73·49	75·61	77·75	79·93	82·13	84·37
12	80·18	82·48	84·82	87·20	89·60	92·04
13	86·86	89·36	91·89	94·46	97·07	99·71
14	93·54	96·23	98·96	101·73	104·53	107·38
15	100·22	103·10	106·03	108·99	112·00	115·05
16	106·90	109·98	113·10	116·26	119·47	122·72
17	113·58	116·85	120·17	123·53	126·93	130·39
18	120·26	123·72	127·23	130·79	134·40	138·06
19	126·95	130·60	134·30	138·06	141·87	145·73
20	133·63	137·47	141·37	145·33	149·33	153·40
21	140·31	144·35	148·44	152·59	156·80	161·07
22	146·99	151·22	155·51	159·86	164·27	168·74
23	153·67	158·09	162·58	167·12	171·73	176·41
24	160·35	164·97	169·65	174·39	179·20	184·08
25	167·03	171·84	176·71	181·66	186·67	191·75
26	173·71	178·71	183·78	188·92	194·13	199·42
27	180·40	185·59	190·85	196·19	201·60	207·09
28	187·08	192·46	197·92	203·46	209·07	214·76
29	193·76	199·33	204·99	210·72	216·54	222·43
30	200·44	206·21	212·06	217·99	224·00	230·10
31	207·12	213·08	219·13	225·25	231·47	237·77
32	213·80	219·95	226·19	232·52	238·94	245·44
33	220·48	226·83	233·26	239·79	246·40	253·11
34	227·17	233·70	240·33	247·05	253·87	260·78
35	233·85	240·58	247·40	254·32	261·34	268·45

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	35	35½	36	36½	37	37½
	Cubic or Square Feet.					
36	240·53	247·45	254·47	261·59	268·80	276·12
37	247·21	254·32	261·54	268·85	276·27	283·79
38	253·89	261·20	268·61	276·12	283·74	291·46
39	260·57	268·07	275·67	283·39	291·20	299·13
40	267·25	274·94	282·74	290·65	298·67	306·80
41	273·93	281·82	289·81	297·92	306·14	314·47
42	280·62	288·69	296·88	305·18	313·60	322·14
43	287·30	295·56	303·95	312·45	321·07	329·81
44	293·98	302·44	311·02	319·72	328·54	337·48
45	300·66	309·31	318·09	326·98	336·00	345·15
46	307·34	316·19	325·15	334·25	343·47	352·82
47	314·02	323·06	332·22	341·52	350·94	360·49
48	320·70	329·93	339·29	348·78	358·40	368·16
49	327·39	336·81	346·36	356·05	365·87	375·83
50	334·07	343·68	353·43	363·31	373·34	383·50
51	340·75	350·55	360·50	370·58	380·80	391·16
52	347·43	357·43	367·57	377·85	388·27	398·83
53	354·11	364·30	374·63	385·11	395·74	406·50
54	360·79	371·17	381·70	392·38	403·20	414·17
55	367·47	378·05	388·77	399·65	410·67	421·84
56	374·15	384·92	395·84	406·91	418·14	429·51
57	380·84	391·79	402·91	414·18	425·60	437·18
58	387·52	398·67	409·98	421·44	433·07	444·85
59	394·20	405·54	417·05	428·71	440·54	452·52
60	400·88	412·42	424·11	435·98	448·00	460·19
65	434·29	446·78	459·46	472·31	485·34	498·54
70	467·69	481·15	494·80	508·64	522·67	536·89
75	501·10	515·52	530·14	544·97	560·00	575·24
80	534·51	549·89	565·49	581·30	597·34	613·59
85	567·91	584·26	600·83	617·63	634·67	651·94
90	601·32	618·62	636·17	653·97	672·01	690·29
95	634·73	652·99	671·51	690·30	709·34	728·64
100	668·13	687·36	706·86	726·63	746·67	766·99

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	38	38½	39	39½	40	40½
	Cubic or Square Feet.					
1	7·88	8·08	8·30	8·51	8·73	8·95
2	15·75	16·17	16·59	17·02	17·45	17·89
3	23·63	24·25	24·89	25·53	26·18	26·84
4	31·50	32·34	33·18	34·04	34·91	35·78
5	39·38	40·42	41·48	42·55	43·63	44·73
6	47·25	48·51	49·77	51·06	52·36	53·68
7	55·13	56·59	58·07	59·57	61·09	62·62
8	63·01	64·68	66·37	68·08	69·81	71·57
9	70·88	72·76	74·66	76·59	78·54	80·52
10	78·76	80·84	82·96	85·10	87·27	89·46
11	86·63	88·93	91·25	93·61	95·99	98·41
12	94·51	97·01	99·55	102·12	104·72	107·35
13	102·39	105·10	107·84	110·63	113·45	116·30
14	110·26	113·18	116·14	119·14	122·17	125·25
15	118·14	121·27	124·44	127·65	130·90	134·19
16	126·01	129·35	132·73	136·16	139·63	143·14
17	133·89	137·44	141·03	144·67	148·35	152·08
18	141·76	145·52	149·32	153·18	157·08	161·03
19	149·64	153·60	157·62	161·69	165·81	169·98
20	157·52	161·69	165·92	170·20	174·53	178·92
21	165·39	169·77	174·21	178·71	183·26	187·87
22	173·27	177·86	182·51	187·22	191·99	196·82
23	181·14	185·94	190·80	195·73	200·71	205·76
24	189·02	194·03	199·10	204·24	209·44	214·71
25	196·89	202·11	207·39	212·75	218·17	223·65
26	204·77	210·19	215·69	221·26	226·89	232·60
27	212·65	218·28	223·99	229·77	235·62	241·55
28	220·52	226·36	232·28	238·28	244·35	250·49
29	228·40	234·45	240·58	246·79	253·07	259·44
30	236·27	242·53	248·87	255·30	261·80	268·39
31	244·15	250·62	257·17	263·80	270·53	277·33
32	252·03	258·70	265·46	272·31	279·25	286·28
33	259·90	266·79	273·76	280·82	287·98	295·22
34	267·78	274·87	282·06	289·33	296·71	304·17
35	275·65	282·95	290·35	297·84	305·43	313·12

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	38	38½	39	39½	40	40½
	CUBIC OR SQUARE FEET.					
36	283·53	291·04	298·65	306·35	314·16	322·06
37	291·40	299·12	306·94	314·86	322·88	331·01
38	299·28	307·21	315·24	323·37	331·61	339·95
39	307·16	315·29	323·53	331·88	340·34	348·90
40	315·03	323·38	331·83	340·39	349·06	357·85
41	322·91	331·46	340·13	348·90	357·79	366·79
42	330·78	339·55	348·42	357·41	366·52	375·74
43	338·66	347·63	356·72	365·92	375·25	384·69
44	346·53	355·71	365·01	374·43	383·97	393·63
45	354·41	363·80	373·31	382·94	392·70	402·58
46	362·29	371·88	381·61	391·45	401·42	411·52
47	370·16	379·97	389·90	399·96	410·15	420·47
48	378·04	388·05	398·20	408·47	418·88	429·42
49	385·91	396·14	406·49	416·98	427·61	438·36
50	393·79	404·22	414·79	425·49	436·33	447·31
51	401·67	412·31	423·08	434·00	445·06	456·25
52	409·54	420·39	431·38	442·51	453·79	465·20
53	417·42	428·47	439·68	451·02	462·51	474·15
54	425·29	436·56	447·97	459·53	471·24	483·09
55	433·17	444·64	456·27	468·04	479·97	492·04
56	441·04	452·73	464·56	476·55	488·69	500·99
57	448·92	460·81	472·86	485·06	497·42	509·93
58	456·80	468·90	481·15	493·57	506·15	518·88
59	464·67	476·98	489·45	502·08	514·87	527·82
60	472·55	485·06	497·75	510·59	523·60	536·77
65	511·93	525·49	539·22	553·14	567·23	581·50
70	551·31	565·91	580·70	595·69	610·86	626·23
75	590·68	606·33	622·18	638·24	654·50	670·96
80	630·06	646·75	663·66	680·79	698·13	715·69
85	669·44	687·18	705·14	723·34	741·76	760·42
90	708·82	727·60	746·62	765·89	785·40	805·16
95	748·20	768·02	788·10	808·43	829·03	849·89
100	787·58	808·44	829·58	850·98	872·66	894·62

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	41	41½	42	42½	43	43½
	CUBIC OR SQUARE FEET.					
1	9·17	9·39	9·62	9·85	10·08	10·32
2	18·34	18·79	19·24	19·70	20·17	20·64
3	27·51	28·18	28·86	29·55	30·25	30·96
4	36·67	37·57	38·48	39·41	40·34	41·28
5	45·84	46·97	48·11	49·26	50·42	51·60
6	55·01	56·36	57·73	59·11	60·51	61·92
7	64·18	65·75	67·35	68·96	70·59	72·24
8	73·35	75·15	76·97	78·81	80·68	82·56
9	82·52	84·54	86·59	88·66	90·76	92·89
10	91·68	93·93	96·21	98·52	100·85	103·21
11	100·85	103·33	105·83	108·37	110·93	113·53
12	110·02	112·72	115·45	118·22	121·02	123·85
13	119·19	122·11	125·07	128·07	131·10	134·17
14	128·36	131·51	134·70	137·92	141·19	144·49
15	137·53	140·90	144·32	147·77	151·27	154·81
16	146·69	150·29	153·94	157·62	161·36	165·13
17	155·86	159·69	163·56	167·48	171·44	175·45
18	165·03	169·08	173·18	177·33	181·52	185·77
19	174·20	178·47	182·80	187·18	191·61	196·09
20	183·37	187·87	192·42	197·03	201·69	206·41
21	192·54	197·26	202·04	206·88	211·78	216·73
22	201·70	206·65	211·66	216·73	221·86	227·05
23	210·87	216·05	221·29	226·59	231·95	237·37
24	220·04	225·44	230·91	236·44	242·03	247·69
25	229·21	234·84	240·53	246·29	252·12	258·02
26	238·38	244·23	250·15	256·14	262·20	268·34
27	247·55	253·62	259·77	265·99	272·29	278·66
28	256·72	263·02	269·39	275·84	282·37	288·98
29	265·88	272·41	279·01	285·69	292·46	299·30
30	275·05	281·80	288·63	295·55	302·54	309·62
31	284·22	291·20	298·25	305·40	312·63	319·94
32	293·39	300·59	307·88	315·25	322·71	330·26
33	302·56	309·98	317·50	325·10	332·80	340·58
34	311·73	319·38	327·12	334·95	342·88	350·90
35	320·89	328·77	336·74	344·80	352·96	361·22

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	41	41½	42	42½	43	43½
	CUBIC OR SQUARE FEET.					
36	330·06	338·16	346·36	354·66	363·05	371·54
37	339·23	347·56	355·98	364·51	373·13	381·86
38	348·40	356·95	365·60	374·36	383·22	392·18
39	357·57	366·34	375·22	384·21	393·30	402·50
40	366·74	375·74	384·84	394·06	403·39	412·82
41	375·90	385·13	394·47	403·91	413·47	423·15
42	385·07	394·52	404·09	413·77	423·56	433·47
43	394·24	403·92	413·71	423·62	433·64	443·79
44	403·41	413·31	423·33	433·47	443·73	454·11
45	412·58	422·70	432·95	443·32	453·81	464·43
46	421·75	432·10	442·57	453·17	463·90	474·75
47	430·91	441·49	452·19	463·02	473·98	485·07
48	440·08	450·88	461·81	472·87	484·07	495·39
49	449·25	460·28	471·43	482·73	494·15	505·71
50	458·42	469·67	481·06	492·58	504·24	516·03
51	467·59	479·06	490·68	502·43	514·32	526·35
52	476·76	488·46	500·30	512·28	524·41	536·67
53	485·93	497·85	509·92	522·13	534·49	546·99
54	495·09	507·24	519·54	531·98	544·57	557·31
55	504·26	516·64	529·16	541·84	554·66	567·63
56	513·43	526·03	538·78	551·69	564·74	577·95
57	522·60	535·42	548·40	561·54	574·83	588·27
58	531·77	544·82	558·02	571·39	584·91	598·60
59	540·94	554·21	567·64	581·24	595·00	608·92
60	550·10	563·60	577·27	591·09	605·08	619·24
65	595·95	610·57	625·37	640·35	655·51	670·84
70	641·79	657·54	673·48	689·61	705·93	722·44
75	687·63	704·51	721·58	738·87	756·35	774·05
80	733·47	751·47	769·69	788·12	806·78	825·65
85	779·31	798·44	817·79	837·38	857·20	877·25
90	825·16	845·41	865·90	886·64	907·62	928·85
95	871·00	892·37	914·00	935·90	958·05	980·46
100	916·84	939·34	962·11	985·16	1008·47	1032·06

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	44	44½	45	46	47	48
	Cubic or Square Feet.					
1	10·56	10·80	11·04	11·54	12·05	12·57
2	21·12	21·60	22·09	23·08	24·10	25·13
3	31·68	32·40	33·13	34·62	36·14	37·70
4	42·24	43·20	44·18	46·16	48·19	50·27
5	52·80	54·00	55·22	57·70	60·24	62·83
6	63·36	64·80	66·27	69·25	72·29	75·40
7	73·91	75·60	77·31	80·79	84·34	87·96
8	84·47	86·40	88·36	92·33	96·39	100·53
9	95·03	97·21	99·40	103·87	108·43	113·10
10	105·59	108·01	110·45	115·41	120·48	125·66
11	116·15	118·81	121·49	126·95	132·53	138·23
12	126·71	129·61	132·54	138·49	144·58	150·80
13	137·27	140·41	143·58	150·03	156·63	163·36
14	147·83	151·21	154·63	161·57	168·68	175·93
15	158·39	162·01	165·67	173·11	180·72	188·50
16	168·95	172·81	176·71	184·66	192·77	201·06
17	179·51	183·61	187·76	196·30	204·82	213·63
18	190·07	194·41	198·80	207·74	216·87	226·19
19	200·63	205·21	209·85	219·28	228·92	238·76
20	211·18	216·01	220·89	230·82	240·96	251·33
21	221·74	226·81	231·94	242·36	253·01	263·89
22	232·30	237·61	242·98	253·90	265·06	276·46
23	242·86	248·41	254·03	265·44	277·11	289·03
24	253·42	259·21	265·07	276·98	289·16	301·59
25	263·98	270·01	276·12	288·52	301·21	314·16
26	274·54	280·82	287·16	300·07	313·25	326·73
27	285·10	291·62	298·21	311·61	325·30	339·29
28	295·66	302·42	309·25	323·15	337·34	351·86
29	306·22	313·22	320·29	334·69	349·40	364·42
30	316·78	324·02	331·34	346·23	361·45	376·99
31	327·34	334·82	342·38	357·77	373·49	389·56
32	337·90	345·62	353·43	369·31	385·54	402·12
33	348·45	356·42	364·47	380·85	397·59	414·69
34	359·01	367·22	375·52	392·39	409·64	427·26
35	369·57	378·02	386·56	403·93	421·69	439·82

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	44	44½	45	46	47	48
	CUBIC OR SQUARE FEET.					
36	380·13	388·82	397·61	415·48	433·74	452·39
37	390·69	399·62	408·65	427·02	445·78	464·96
38	401·25	410·42	419·70	438·56	457·83	477·52
39	411·81	421·22	430·74	450·10	469·88	490·09
40	422·37	432·02	441·79	461·64	481·93	502·65
41	432·93	442·82	452·83	473·18	493·98	515·22
42	443·49	453·62	463·88	484·72	506·03	527·79
43	454·05	464·42	474·92	496·26	518·07	540·35
44	464·61	475·23	485·96	507·80	530·12	552·92
45	475·17	486·03	497·01	519·34	542·17	565·49
46	485·72	496·83	508·05	530·89	554·22	578·05
47	496·28	507·63	519·10	542·43	566·27	590·62
48	506·84	518·43	530·14	553·97	578·31	603·19
49	517·40	529·23	541·19	565·51	590·36	615·75
50	527·96	540·03	552·23	577·05	602·41	628·32
51	538·52	550·83	563·28	588·59	614·46	640·88
52	549·08	561·63	574·32	600·13	626·51	653·45
53	559·64	572·43	585·37	611·67	638·56	666·02
54	570·13	583·23	596·41	623·21	650·60	678·58
55	580·76	594·03	607·46	634·75	662·65	691·15
56	591·32	604·83	618·50	646·29	674·70	703·72
57	601·88	615·63	629·55	657·84	686·75	716·28
58	612·44	626·43	640·59	669·38	698·80	728·85
59	622·99	637·23	651·63	680·92	710·84	741·42
60	633·55	648·03	662·68	692·46	722·89	753·98
65	686·35	702·04	717·91	750·17	783·13	816·81
70	739·15	756·04	773·13	807·87	843·38	879·65
75	791·94	810·04	828·35	865·57	903·62	942·48
80	844·74	864·05	883·57	923·28	963·86	1005·31
85	897·53	918·05	938·80	980·98	1024·10	1068·14
90	950·33	972·05	994·02	1038·69	1084·34	1130·97
95	1003·13	1026·06	1049·24	1096·40	1144·58	1193·80
100	1055·92	1080·06	1104·47	1154·10	1204·82	1256·64

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	49	50	51	52	53	54
	CUBIC OR SQUARE FEET.					
1	13·10	13·64	14·19	14·75	15·32	15·90
2	26·19	27·27	28·37	29·50	30·64	31·81
3	39·29	40·91	42·56	44·24	45·96	47·71
4	52·38	54·54	56·74	58·99	61·28	63·62
5	65·48	68·18	70·93	73·74	76·60	79·52
6	78·57	81·81	85·12	88·49	91·92	95·43
7	91·67	95·45	99·30	103·24	107·24	111·33
8	104·76	109·08	113·49	117·98	122·57	127·23
9	117·86	122·72	127·68	132·73	137·89	143·14
10	130·95	136·35	141·86	147·48	153·21	159·04
11	144·05	149·99	156·05	162·23	168·53	174·95
12	157·14	163·62	170·23	176·98	183·85	190·85
13	170·24	177·26	184·42	191·72	199·17	206·76
14	183·34	190·90	198·61	206·47	214·49	222·66
15	196·43	204·53	212·79	221·22	229·81	238·56
16	209·53	218·17	226·98	235·97	245·13	254·47
17	222·62	231·80	241·17	250·72	260·45	270·37
18	235·72	245·44	255·35	265·46	275·77	286·28
19	248·81	259·07	269·54	280·21	291·09	302·18
20	261·91	272·71	283·72	294·96	306·41	318·09
21	275·00	286·34	297·91	309·71	321·73	333·99
22	288·10	299·98	312·10	324·46	337·06	349·89
23	301·19	313·61	326·28	339·20	352·38	365·80
24	314·29	327·25	340·47	353·95	367·70	381·70
25	327·39	340·88	354·66	368·70	383·02	397·61
26	340·48	354·52	368·84	383·45	398·34	413·51
27	353·58	368·16	383·03	398·20	413·66	429·42
28	366·67	381·79	397·21	412·94	428·98	445·32
29	379·77	395·43	411·40	427·69	444·30	461·22
30	392·86	409·06	425·59	442·44	459·62	477·13
31	405·96	422·70	439·77	457·19	474·94	493·03
32	419·05	436·33	453·96	471·94	490·26	508·94
33	432·15	449·97	468·15	486·68	505·58	524·84
34	445·24	463·60	482·33	501·43	520·90	540·75
35	458·34	477·24	496·52	516·18	536·22	556·65

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	49	50	51	52	53	54
	Cubic or Square Feet.					
36	471·43	490·87	510·70	530·93	551·55	572·55
37	484·53	504·51	524·89	545·68	566·87	588·46
38	497·63	518·14	539·08	560·42	582·19	604·36
39	510·72	531·78	553·26	575·17	597·51	620·27
40	523·82	545·42	567·45	589·92	612·83	636·17
41	536·91	559·05	581·64	604·67	628·15	652·08
42	550·01	572·69	595·82	619·42	643·47	667·98
43	563·10	586·32	610·01	634·16	658·79	683·88
44	576·20	599·96	624·19	648·91	674·11	699·79
45	589·29	613·59	638·38	663·66	689·43	715·69
46	602·39	627·23	652·57	678·41	704·75	731·60
47	615·48	640·86	666·75	693·16	720·07	747·50
48	628·58	654·50	680·94	707·91	735·39	763·41
49	641·68	668·13	695·13	722·65	750·71	779·31
50	654·77	681·77	709·31	737·40	766·04	795·22
51	667·87	695·40	723·50	752·15	781·36	811·12
52	680·96	709·04	737·68	766·90	796·68	827·02
53	694·06	722·67	751·87	781·65	812·00	842·93
54	707·15	736·31	766·06	796·39	827·32	858·83
55	720·25	749·95	780·24	811·14	842·64	874·74
56	733·34	763·58	794·43	825·89	857·96	890·64
57	746·44	777·22	808·62	840·64	873·28	906·55
58	759·53	790·85	822·80	855·39	888·60	922·45
59	772·63	804·49	836·99	870·13	903·92	938·35
60	785·72	818·12	851·17	884·88	919·24	954·26
65	851·20	886·30	922·11	958·62	995·85	1033·78
70	916·68	954·48	993·04	1032·36	1072·45	1113·30
75	982·16	1022·65	1063·97	1106·10	1149·05	1192·82
80	1047·63	1090·83	1134·90	1179·84	1225·66	1272·34
85	1113·11	1159·01	1205·83	1253·58	1302·26	1351·87
90	1178·59	1227·18	1276·76	1327·32	1378·86	1431·39
95	1244·06	1295·36	1347·69	1401·06	1455·47	1510·91
100	1309·54	1363·54	1418·62	1474·80	1532·07	1590·43

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	55	56	57	58	59	60
	Cubic or Square Feet.					
1	16·50	17·10	17·72	18·35	18·99	19·63
2	33·00	34·21	35·44	36·70	37·97	39·27
3	49·50	51·31	53·16	55·04	56·96	58·90
4	66·00	68·42	70·88	73·39	75·94	78·54
5	82·49	85·52	88·60	91·74	94·93	98·17
6	98·99	102·63	106·32	110·09	113·92	117·81
7	115·49	119·73	124·04	128·43	132·90	137·44
8	131·99	136·83	141·76	146·78	151·89	157·08
9	148·49	153·94	159·48	165·13	170·87	176·71
10	164·99	171·04	177·21	183·48	189·86	196·35
11	181·49	188·15	194·93	201·83	208·84	215·98
12	197·99	205·25	212·65	220·17	227·83	235·62
13	214·48	222·35	230·37	238·52	246·82	255·25
14	230·98	239·46	248·09	256·87	265·80	274·89
15	247·48	256·56	265·81	275·22	284·79	294·52
16	263·98	273·67	283·53	293·56	303·77	314·16
17	280·48	290·77	301·25	311·91	322·76	333·79
18	296·98	307·88	318·97	330·26	341·75	353·43
19	313·48	324·98	336·69	348·61	360·73	373·06
20	329·98	342·08	354·41	366·96	379·72	392·70
21	346·47	359·19	372·13	385·30	398·70	412·33
22	362·97	376·29	389·85	403·65	417·69	431·97
23	379·47	393·40	407·57	422·00	436·68	451·60
24	395·97	410·50	425·29	440·35	455·66	471·24
25	412·47	427·61	443·01	458·69	474·65	490·87
26	428·97	444·71	460·73	477·04	493·63	510·51
27	445·47	461·81	478·45	495·39	512·62	530·14
28	461·97	478·92	496·17	513·74	531·61	549·78
29	478·47	496·02	513·90	532·09	550·59	569·41
30	494·96	513·13	531·62	550·43	569·58	589·05
31	511·46	530·23	549·34	568·78	588·56	608·68
32	527·96	547·33	567·06	587·13	607·55	628·32
33	544·46	564·44	584·78	605·48	626·53	647·95
34	560·96	581·54	602·50	623·82	645·52	667·59
35	577·46	598·65	620·22	642·17	664·51	687·22

Length (feet) or number of Stems.	DIAMETER IN INCHES.					
	55	56	57	58	59	60
	CUBIC OR SQUARE FEET.					
36	593·96	615·75	637·94	660·52	683·49	706·86
37	610·46	632·86	655·66	678·87	702·48	726·49
38	626·95	649·96	673·38	697·21	721·46	746·13
39	643·45	667·06	691·10	715·56	740·45	765·76
40	659·95	684·17	708·82	733·91	759·44	785·40
41	676·45	701·27	726·54	752·26	778·42	805·03
42	692·95	718·38	744·26	770·61	797·41	824·67
43	709·45	735·48	761·98	788·95	816·39	844·30
44	725·95	752·59	779·70	807·30	835·38	863·94
45	742·45	769·69	797·42	825·65	854·37	883·57
46	758·94	786·79	815·14	844·00	873·35	903·21
47	775·44	803·90	832·87	862·34	892·34	922·84
48	791·94	821·00	850·59	880·69	911·32	942·48
49	808·44	838·11	868·31	899·04	930·31	962·11
50	824·94	855·21	886·03	917·39	949·29	981·75
51	841·44	872·31	903·75	935·74	968·28	1001·38
52	857·94	889·42	921·47	954·08	987·27	1021·02
53	874·44	906·52	939·19	972·43	1006·25	1040·65
54	890·94	923·63	956·91	990·78	1025·24	1060·29
55	907·43	940·73	974·63	1009·13	1044·22	1079·92
56	923·93	957·84	992·35	1027·47	1063·21	1099·56
57	940·43	974·94	1010·07	1045·82	1082·20	1119·19
58	956·93	992·04	1027·79	1064·17	1101·18	1138·83
59	973·43	1009·15	1045·51	1082·52	1120·17	1158·46
60	989·93	1026·25	1063·23	1100·87	1139·15	1178·10
65	1072·42	1111·77	1151·83	1192·60	1234·08	1276·27
70	1154·92	1197·29	1240·44	1284·34	1329·01	1374·45
75	1237·41	1282·82	1329·04	1376·08	1423·94	1472·62
80	1319·90	1368·34	1417·64	1467·82	1518·87	1570·80
85	1402·40	1453·86	1506·25	1559·56	1613·80	1668·97
90	1484·89	1539·38	1594·85	1651·30	1708·73	1767·14
95	1567·39	1624·90	1683·45	1743·04	1803·66	1865·32
100	1649·88	1710·42	1772·05	1834·78	1898·59	1963·49

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THE END.

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